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CITY OF BALTIMORE

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CONTRACT RP 24821R

Volume 3 of 3

FOR

PATTERSON PARK POOL HOUSE RENOVATION

148 S LINWOOD AVE, BALTIMORE, MD 21224

SECTION 22 33 00 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Commercial, electric, storage, domestic-water heaters.

2. Domestic-water heater accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of commercial electric, domestic-water heater.

B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

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

1.6 COORDINATION

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

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.

b. Faulty operation of controls.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: Five years.

2) Controls and Other Components: Five years.

b. Expansion Tanks: Five years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:

1. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.

2. Standard: UL 1453.

3. Storage-Tank Construction: ASME-code, steel vertical arrangement.

   a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

      1) NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.

      2) NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.

   b. Pressure Rating: 150 psig.

   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed, Storage-Tank Appurtenances:

   a. Anode Rod: Replaceable magnesium.

   b. Drain Valve: Corrosion-resistant metal with hose-end connection.

   c. Insulation: Comply with ASHRAE/IES 90.1.

   d. Jacket: Steel with enameled finish or high-impact composite material.

   e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.

   f. Temperature Control: Adjustable thermostat.

   g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.

   h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.

2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

3. Construction:

   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.

b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

c. Air-Charging Valve: Factory installed.

4. Capacity and Characteristics:

a. Working-Pressure Rating: 150 psig.

b. Capacity Acceptable: 7 gal. minimum.

c. Air Precharge Pressure:

B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1 and ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE/IES 90.1 and ASHRAE 90.2.

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

F. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.

G. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

H. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 03 30 00 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.

2. Maintain manufacturer's recommended clearances.

3. Arrange units so controls and devices that require servicing are accessible.

4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Install anchor bolts to elevations required for proper attachment to supported equipment.

8. Anchor domestic-water heaters to substrate.

B. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

G. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

H. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

I. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

J. Fill electric, domestic-water heaters with water.

K. Charge domestic-water expansion tanks with air to required system pressure.

L. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.

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

E. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters. Training shall be a minimum of two hours.

END OF SECTION

SECTION 22 42 13 – PLUMBING FIXTURES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets for lavatories and sinks.
2. Flushometers.
3. Toilet seats.
4. Fixture supports.
5. Water closets.
6. Urinals
7. Lavatories.
8. Showers
9. Kitchen sinks
10. Mop Basins

B. Related Sections include the following:

1. Division 22 Section "Domestic Water Piping Specialties" for floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

A. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

B. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

C. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects", for fixture materials that will be in contact with potable water.

D. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

E. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.

2. Vitreous-China Fixtures: ASME A112.19.2M.

3. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.

F. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.

2. Faucets: ASME A112.18.1.

3. Hose-Coupling Threads: ASME B1.20.7.

4. Integral, Atmospheric Vacuum Breakers: ASSE 1001.

5. NSF Potable-Water Materials: NSF 61.

6. Pipe Threads: ASME B1.20.1.

7. Supply Fittings: ASME A112.18.1.

8. Brass Waste Fittings: ASME A112.18.2.

9. Thermostatic, antiscald device: ASSE 1070

G. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.

2. Brass and Copper Supplies: ASME A112.18.1.

3. Manual-Operation Flushometers: ASSE 1037.

4. Brass Waste Fittings: ASME A112.18.2.

H. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Flexible Water Connectors: ASME A112.18.6.

2. Floor Drains: ASME A112.6.3.

3. Hose-Coupling Threads: ASME B1.20.7.

4. Off-Floor Fixture Supports: ASME A112.6.1M.

5. Pipe Threads: ASME B1.20.1.

6. Plastic Toilet Seats: ANSI Z124.5.

7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of plumbing fixtures that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures of unit shell.

b. Faulty operation.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period: One year from date of Substantial Completion.

PART 2 PRODUCTS

2.1 FAUCETS

A. Faucets: See Plumbing Fixtures and accessories on Drawings.

2.2 FLUSHOMETERS

A. Flushometers: See Plumbing Fixtures and accessories on Drawings.

2.3 TOILET SEATS

A. Toilet Seats: See Plumbing Fixtures and accessories on Drawings.

2.4 WATER CLOSETS

A. Water Closets: See Plumbing Fixtures and accessories on Drawings.

2.5 URINALS

A. Urinals: See Plumbing Fixtures and accessories on Drawings.

2.6 LAVATORIES

A. Lavatories: See Plumbing Fixtures and accessories on Drawings.

2.7 SHOWERS

A. Showers: See Plumbing Fixtures and accessories on Drawings.

2.8 KITCHEN SINKS

A. Kitchen Sinks: See Plumbing Fixtures and accessories on Drawings.

2.9 SERVICE SINKS

A. Service Sinks: See Plumbing Fixtures and accessories on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

C. Install wall-mounting fixtures with tubular waste piping attached to supports.

D. Install counter-mounting fixtures in and attached to casework.

E. Install fixtures level and plumb according to roughing-in drawings.

F. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

G. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

H. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

I. Install toilet seats on water closets.

J. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

K. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

L. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts.

M. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.

2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

N. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division Section 220518.

O. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

E. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sink.

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.

2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

END OF SECTION

SECTION 22 45 00 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency shower and eye / face wash.

2. Water-tempering equipment.

1.2 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Tepid: Between 60 and 100 deg F.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings:

1. Plans, elevations, sections, and mounting and attachment details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Submittals:

1. Field quality-control reports.

B. Emergency fixture third-party certification documentation.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI/ISEA Z358.1 for emergency plumbing fixtures including third-party certification of fixtures.

B. Comply with ASSE 1071 for temperature-actuated mixing valves for plumbed emergency fixtures.

C. Comply with ASME A112.18.1/CSA B125.1 for water-supply fittings.

D. Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.

E. Comply with NSF 61 and NSF 372 for fixture materials that will be in contact with potable water.

F. Comply with requirements in ICC A117.1 for plumbing fixtures for people with disabilities.

2.2 EMERGENCY SHOWER AND EYE / FACE WASH

A. Refer to the drawings for product requirements concerning emergency shower and eye face wash.

2.3 WATER-TEMPERING EQUIPMENT

A. Refer to the drawings for product requirements concerning water tempering equipment (thermostatic mixing valve).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATON OF EMERGENCY PLUMBING FIXTURE

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for

operation. Comply with requirements for valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 22 11 16 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

G. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

H. Fill self-contained fixtures with flushing fluid.

3.3 PIPING CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 22 11 16 "Domestic Water Piping."

B. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Operate and adjust emergency plumbing fixtures and controls. Replace damaged and malfunctioning fixtures and controls.

B. Adjust or replace fixture flow regulators for proper flow.

C. Adjust equipment temperature settings.

3.7 CLEANING AND PROTECTION

A. Clean emergency plumbing fixtures with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed emergency plumbing fixtures and fittings.

C. Do not allow use of emergency plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 23 00 00 – BASIC MECHANICAL REQUIREMENTS – HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements, as well as the following basic mechanical materials and methods:

1. Codes, organizations, standards, and abbreviations
2. Responsibility
3. Site visit
4. Submittals
5. Variances
6. Performance requirements
7. Material and equipment
8. Coordination, sequencing and scheduling
9. Fire safe materials
10. UL requirements
11. Warranty / Guarantee
12. Listed manufacturers
13. Approved equal equipment layouts
14. Coordination drawings
15. Construction record documents.
16. Operation and maintenance manuals
17. Concrete equipment bases
18. Grout
19. Combination motor starters, VFD, and controllers – HVAC equipment
20. General requirements - execution

21. Equipment roughins
22. Mechanical installation - HVAC
23. Cutting and patching
24. Cutting, welding and burning
25. Painting and finishing
26. Concrete bases
27. Erection of metal supports and anchorage
28. Demolition
29. Grout
30. Penetration of water proof construction
31. Excavation and backfilling
32. Cleaning and Finishes
33. Lintels
34. Electrical requirements
35. Provisions for access
36. Operation of equipment
37. Temporary service and equipment use
38. Demonstration and instructions
39. Lubrication
40. Wall and floor penetrations
41. Equipment provided under another division and by others
42. Construction record drawings
43. Closeout procedures
44. Clean up
45. Project punchout

1.3 CODES, ORGANIZATIONS, STANDARDS AND ABBRIVIATIONS

A. Codes: All material and equipment provided and installed as part of these construction documents shall be in compliance with the latest edition of the following codes as adapted by the State of Maryland and Baltimore City for the following:

1. International Building Code (IBC)
2. International Mechanical Code (IMC)
3. International Plumbing Code (IPC)
4. National Electric Code (NEC)
5. Maryland State Health Department
6. Underwriters Laboratories (UL)
7. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilation Systems
8. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
9. NFPA 101: Life Safety Code

B. Organizations and Standards: The following list of organizations and standards are referenced in the HVAC Specification Sections and are included here for reference:

1. AABC: Associated Air Balance Council
2. ADC: Air Diffusion Council
3. AEC: Architecture, Engineering and Construction
4. AGA: American Gas Association
5. AHRI: Air Conditioning, Heating and Refrigeration Institute
6. AMCA: Air Moving and Conditioning Association
7. ANSI: American National Standards Institute
8. API: American Petroleum Institute
9. ARI: Air Conditioning and Refrigeration Institute
10. ASCE: American Society of Civil Engineers
11. ASCE-SEI: American Society of Civil Engineers - Structural Engineering Institute
12. ASHRAE- American Society of Heating, Refrigerating and Air Conditioning Engineers
13. ASME: American Society of Mechanical Engineers
14. ASTM: American Society for Testing and Materials
15. AWS: American Welding Society
16. AWWA: American Water Works Association

17. BAS: Building Automation System
18. CFR: Code of Federal Regulations
19. CGA: Compressed Gas Association
20. CS: Commercial Standard
21. CSA: Canadian Standards Association
22. CTI STD: Cooling Technology Institute - Standard
23. CTI ATC: Cooling Technology Institute – Acceptable Test Code
24. EJMA: Expansion Joint Manufacturers Association
25. EPA: Environmental Protection Agency
26. FM: Facilities Management
27. FMG: Factory Mutual Global
28. FSA: Fuel Sealing Association
29. FSA – NMEJ: Fuel Sealing Association - Non-Metallic Expansion Joint
30. IAPMO: International Association of Plumbing and Mechanical Officials
31. IBR: Institute of Boiler and Radiator Manufacturers
32. ICC: International Code Council
33. ICC–ES: International Conference on Computational & Experimental Engineering and Sciences
34. IEC: International Electrotechnical Commission
35. IEEE: Institute of Electrical and Electronics Engineers
36. IESNA: Illuminating Engineering Society of North America
37. ISO: International Organization for Standardization
38. ITT: International Telephone & Telegraph Corporation
39. MOSHA- Maryland Occupational Safety and Health Administration
40. MSHA: Mine Safety and Health Administration
41. MSS: Manufacturers Standardization Society
42. MSSP: Manufacturers Standards Society of the Valve and Fittings Industry
43. MSS SP: Manufacturers Standardization Society Standard Practice
44. NADCA: National Air Duct Cleaners Association

45. NAIMA: North American Insulation Manufacturers Association.

46. NAIMA – AH: North American Insulation Manufacturers Association – Air Handling

47. NEBB: National Environmental Balancing Bureau

48. NEC: National Electric Code

49. NEMA: National Electrical Manufacturers Association

50. NEMA – ICS: National Electrical Manufacturers Association – Industrial Control and Systems

51. NEMA – KS: National Electrical Manufacturers Association – Kansas

52. NEMA – MG: National Electrical Manufacturers Association – Motors & Generators

53. NFPA: National Fire Protection Association

54. NICET: National Institute for Certification in Engineering Technologies

55. NIOSH: National Institute for Occupational Safety and Health

56. OSHA - Occupational Safety and Health Administration

57. SE: System Engineering

58. SEI: Software Engineering Institute

59. SMACNA- Sheet Metal and Air Conditioning Contractors National Association

60. TEMA: Tubular Exchanger Manufacturers Association

61. ULC: Underwriters' Laboratories – Canada

C. Abbreviations: The following list of abbreviations are referenced in the HVAC Specification Sections and are included here for reference:

1. A/C: Air Conditioning
2. ADA: American Disability Act
3. ASJ: All Service Jacket
4. ATC: Automatic temperature Control
5. BACnet: Building Automation and Control Networks
6. BACnet IP: Internet Protocol
7. BACnet MSTP: Master Slave Token Passing
8. BACnet TCP: Transmission Control Protocol
9. BAS: Building Automation System

10. BMS: Building Management System
11. BTU: British Thermal Unit
12. CAD: Computer Aided Design
13. CD-ROM: Compact Disk – Read Only Material
14. CFC: Chlorofluorocarbon
15. CFM: Cubic Feet per Minute
16. CM: Construction Manager
17. Corp: Corporation
18. CV: Coefficient of Variation, Constant Volume
19. CWP: Cold Working Pressure
20. °C: Degree Celsius
21. °F: Degree Fahrenheit
22. DDC: Direct Digital Control
23. DIA: Diameter
24. DOC: Document
25. DOP: Dispersed Oil Particle
26. DP: Differential Pressure
27. Dwg: Drawing
28. EEPROM: Electrically Erasable, Programmable Read-Only Memory
29. EMT: Electrical Metallic Tubing
30. EDPM: Ethylene Propylene Diene Terpolymer Rubber
31. FCU: Fan Coil Unit
32. FHETU: Fume Hood Exhaust Terminal Unit
33. FIT: Fast Installation Technique
34. FLN: Floor Local Network
35. FNPT: Female National Pipe Thread
36. FPM: Feet Per Minute
37. FRP: Fiberglass Reinforced Pipe

38. FSK: Foil Scrim Kraft
39. FTU: Fin Tube
40. $Ft.^2$: Square Feet
41. GAL: Gallon(s)
42. GETU: General Exhaust Terminal Unit
43. GFI: Ground Fault Interrupter
44. GPM: Gallons Per Minute
45. HCFC: Hydrochlorofluorocarbons
46. HEPA: High Efficiency Particulate Absorption
47. Hr: Hour
48. H_g: Mercury
49. HP: Horse Power
50. HVAC: Heating Ventilation and Air Conditioning
51. H_z: Hertz
52. IBC: International Building Code
53. IEQ: Indoor Environmental Quality
54. Inc: Incorporated
55. ID: Inside Diameter
56. IN: Inches
57. Khz: Kilohertz
58. KVA: Kilo Volt Ampere
59. KVAR: Kilo Volt Amperes, Reactive
60. KVARH: Kilo Volt Amps Reactive Hours
61. kW: Kilowatt
62. LAN: Local Area Network
63. Lb: Pound
64. Lbf/inch: Pound Force per Inch
65. Lbs: Pounds

66. LCD: Liquid Crystal Display
67. LED: Light Emitting Diode
68. mA: Milli Ampere
69. mL: Milli Liter
70. MAX: Maximum
71. MERV: Minimum Efficiency Rating Value
72. MIN: Minimum
73. MPa: Megapascal
74. N/A: Not Applicable
75. NBR: Nitrile Butadiene Rubber
76. NEC: National Electric Code
77. NG: Natural Gas
78. NMEJ: Non-Metallic Expansion Joint
79. No.: Number
80. NOM: Nominal
81. NPS: Nominal Pipe Size
82. NPT: National Pipe Thread
83. NRC: Noise Reduction Coefficient
84. OC: On Center
85. OD: Outside Diameter
86. ODP: Open Drip Proof
87. OZ: Ounce
88. PD: Pressure Drop
89. Pdf: Portable Document Format
90. pH: Potassium Hydrogen
91. PPM: Parts per Million
92. PPS: Plastic Pipe Systems
93. PSI: Pounds per Square Inch

94. PSIG: Pounds per Square Inch Gage

95. P/T: Pressure/Temperature

96. PTFE: Polytetraflouroethylene

97. PVC: Polyvinyl Chloride

98. RO: Reverse Osmosis

99. RO/DI: Reverse Osmosis/Distilled Water

100. RPM: Revolutions per Minute

101. RPTFE: Reinforced PolyTetraFluoroEthylene

102. S/S: Stainless Steel

103. STC: Sound Transmission Class

104. STU: Supply Terminal Unit

105. Sq.yd.: Square Yard

106. TAB: Testing, Adjusting, and Balancing

107. TEAO: Totally Enclosed Air Over Enclosure

108. TEC: Terminal Equipment Controller

109. TENV: Totally Enclosed Non Ventilating Enclosure

110. TFE: Tetrafluoroethylene, Trifluoroethanol?

111. TORR: Unit of Pressure Equal to 1/760 Atmosphere

112. TRU: Terminal Reheat Unit

113. TSS: Total Suspended Solids

114. UH: Unit Heater

115. US: United States

116. USA: United States of America

117. USB: Universal Serial Bus

118. UPS: Uninterrupted Power Supply

119. UV: Ultraviolet

120. V: Volt

121. VAV: Variable Air Volume

122. VOC: Volatile Organic Compounds

123. VSD: Variable Speed Drive

124. WG: Water Gage

1.4 RESPONSIBILITY

A. The Construction Manager/General Contractor (CM/GC) shall be responsible for all work included in Division 23. The delegation of work to the contractors shall not relieve them of this responsibility. Contractors who perform the work under this Division shall be responsible to the CM/GC.

1.5 SUBMITTALS

A. General: For general requirements see Architectural Specification Division 01 Section "Submittal Procedures".

B. HVAC Submittals: Provide submittals for all material, equipment and/or supports as specified in Division 23 and where indicated on the drawings and details. For material and product data submission requirements see Division 23 Specification Sections. At a minimum the following submittals shall be provided as required by the project unless otherwise noted:

1. Pipe, fittings and accessories for each system.
2. Valves, strainers and unions for each system.
3. Insulation (pipe, duct and equipment).
4. Hangers and supports.
5. AHU's.
6. Energy recovery equipment.
7. Packaged rooftop units.
8. Air Devices.
9. Duct systems.
10. Building automation system.
11. Identification (labels, tags valve schedule).
12. Equipment supports.
13. Coordinated drawings.
14. Warranties and maintenance instructions shall be included in the O & M Manual only. Do not include this data in the Product Submittals.

C. Submittal File Format: File formats for each submittal shall be electronically as follows:

1. Product Data File: "pdf" file format.
2. Drawings: "pdf" and "dwg" formats.
3. Coordinated Drawings: "pdf" or "dwg" file formats.
4. Schedules: "xl" file format.

1.6 VARIANCES

A. Where variances occur between the drawings and specifications or within either document itself, the item or arrangement of better quality, greater quantity or higher cost shall be included in the contract price. The Engineer shall decide on the item and manner in which the work shall be provided.

1.7 PERFORMANCE REQUIREMENTS

A. Contract drawings are generally diagrammatic and do not indicate all offsets, fittings, transitions, access panels and other specialties required.

B. Arrange HVAC piping, ductwork, equipment and other work generally as shown on the contract drawings, providing proper clearances and access.

C. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawing submittal for approval in accordance with Submittals specified below.

D. The Architect may make reasonable changes in location of equipment piping and ductwork up to the time of rough-in or fabrication.

1.8 MATERIALS AND EQUIPMENT

A. The contract drawings and system performances have been designed on the basis of using the particular manufacturer's products specified or scheduled on the contract drawings.

B. Products of other manufacturer's listed in the specification shall be permitted provided as follows:

1. Products meet all of the requirements of the specifications.
2. Make, without additional cost to the Owner, all adjustments for deviations, such that the final installation is complete and functions as the basis of design product is intended.

C. Products with dimensions or other characteristics different from the basis of design product that render their use impractical or cause functional fit, access, or connection problems, shall not be acceptable.

1.9 COORDINATION, SEQUENCING AND SCHEDULING

A. Coordinate HVAC systems, equipment, and materials installation with other building components.

B. Utilities: Coordinate connection of HVAC systems with exterior underground services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

C. Chases: Arrange for chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Sleeves: Coordinate the installation of required supporting devices and set sleeves in poured in place concrete and other structural components as they are constructed.

E. Sequencing: Sequence, coordinate, and integrate installations of HVAC materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

F. Electrical Services: Coordinate connection of electrical services.

G. Access: Coordinate requirements for access panels and doors where HVAC items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Architectural Specification Section "Access Doors."

H. Scheduling: Schedule and coordinate the delivery of material and equipment with other trades to avoid delivery conflicts.

1.10 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials shall conform to UL, NFPA or ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of twenty five (25) and smoke developed of fifty (50).

1.11 UNDERWRITER'S LABORATORY (UL) REQUIREMENTS

A. All equipment containing electrical components and provided as part of the mechanical specifications shall bear the Underwriter's Laboratory (UL) label, as a complete packaged system.

1. Equipment not provided with a UL label shall be tested in the field, certified and provided with a UL label at the installer's expense.

2. Field testing shall be performed by a testing agency approved by the authority having jurisdiction.

1.12 WARRANTY/GUARANTEE

A. All materials, equipment, etc. provided by the general contractor and/or his subcontractors shall be warranted and guaranteed to be free from defects in workmanship and materials for a period of two (2) years from the date of substantial completion and acceptance of work by the Owner. Any defects in workmanship, materials, or performance which appear within the guarantee period shall be corrected by the contractor without cost to the owner, within a reasonable time, to be specified by the Owner. In default thereof, owner may have such work done and charge the cost of same to the contractor. In addition to the above statement the Warranty/Guarantee

Period shall also include all labor cost related to all warranty work. For compressorized equipment include an additional three (3) year Warranty/Guarantee Period.

PART 2 PRODUCTS

2.1 LISTED MANUFACTURERS

A. Listed Manufacturers: The listed manufacturers indicated in Part 2 of each specification section as the basis of design represents the minimum level of quality for materials and equipment that is acceptable to the Owner. Unless otherwise indicated in each specification section, contractors may submit material and equipment by non listed manufacturers provided said submittals meet all of the requirements of these specifications. All submitted materials and equipment are subject to approval by the A/E.

2.2 APPROVED EQUAL EQUIPMENT LAYOUTS

A. Approved Equal Equipment Layouts: The equipment layouts and the related mechanical and electrical service connections, access space and supports indicated on the construction documents represent equipment provided by the specified basis of design manufacturer and model number. When the successful bidder chooses to provide "or approved equal" equipment by one (1) of the other listed manufacturers in the specifications, the bidder shall be responsible for providing all adjustments and modifications to the services necessary to make connections to the equipment, the bidder shall be responsible for installing the equipment such that all required clear access space is maintained, and the bidder shall be responsible for providing all adjustments and modifications to the equipment mounting and supports. All adjustments and modifications shall be provided by the bidder and appropriate subcontractors at no additional cost to the project.

2.3 COORDINATION DRAWINGS

A. General: When required participate in the preparation of the coordinated drawing effort for the project. See Specification Division 01 for General Requirements.

B. Coordination Drawings: In addition to the requirements of the Specification Division 01 prepare the HVAC part for the coordination drawing effort. Work with the other trades to ensure the material and equipment installed as part on the HVAC system will not be in conflict with the installation of material and equipment by the other trade contractors. Unless otherwise indicated the coordination drawings, including plans, sections, and elevations shall be prepared at a scale of not less than 1/4 inch = 1 foot- 0 inches. At a minimum, prepare coordination drawings for all mechanical rooms, electrical rooms and substation rooms.

C. File Format: Coordination drawings shall be in a layered structure form as CAD Files or PDF Files for each floor with searchable text as follows:

1. File Structure: The "pdf" or "dwg" files shall have separate layered structure for:
   a. Building Elements: Indicate each building element on separate layers, such as:
      1) Walls.
      2) Reflected ceiling plan.
      3) Room numbers.
   b. Systems and Sub Systems: Indicate each system or sub system as warranted by congestion or complexity on separate layers such as:

1) Examples of Systems:
   a) Air Distribution System.
2) Examples of Sub Systems:
   a) General Exhaust System.

2. The layered electronic files shall allow building elements, building systems and sub systems to be viewed in isolation or in combinations that are user selectable when the drawing files are being displayed.

D. Coordination Effort: This coordination effort shall include detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the work, including (but not necessarily limited to) the following

1. Indicate the proposed locations of HVAC system piping, valves, equipment, and materials. Include the following:
   a. Clearances for servicing and maintaining equipment, including, the space for equipment disassembly required for periodic maintenance.
   b. Exterior wall and foundation penetrations.
   c. Sizes and location of required concrete pads and bases.
   d. Size and location of pipe hangers and other components for pipe supports.
   e. All HVAC system roughins for equipment.
   f. Access doors.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations. Show all wall mounted access doors for mechanical devices.

4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, cable trays, sprinklers, access doors and other ceiling mounted items.

2.4 CONSTRUCTION RECORD DOCUMENTS

A. The mechanical contractor shall maintain a set of construction record documents during the construction period in accordance with Specification Division 01 Section "Project Closeout".

2.5 PROJECT OPERATION AND MAINTENANCE MANUAL – ELECTRONIC FILES

A. Project O & M Manual File: The project OM Manual shall include one (1) electronic copy of each approved submittal and any manufacturer's maintenance manuals, and all warranty certificates included in Division 23. Also include the address, phone number and contact person for each supplier. Insert the submittal files include both a book mark and tree structure for accessing each submittal file in the manual.

2.6 CONCRETE EQUIPMENT BASES

A. Concrete: 3,500 psi compressive strength after twenty eight (28) days.

B. Grout shall be non-shrink, high strength type, free of iron or chlorides and suitable for use in contact with all metals, without caps or other protective finishes.

2.7 GROUT

A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.

1. Characteristics: Post hardening, volume adjusting, dry, hydraulic cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5,000-psi (34.50MPa), twenty eight (28) day compressive strength.

3. Packaging: Premixed and factory-packaged.

2.8 COMBINATION MOTOR STARTERS, VFD'S, AND CONTROLLERS – HVAC EQUIPMENT

A. Combination motor starters, VFD's and/or controllers shall be provided for all motors serving HVAC equipment as follows:

1. Combination motor starters, VFD's and/or controllers shall be provided by the equipment manufacturer as part of Division 23.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS – EXECUTION

A. All construction work that creates excessive noise will not be permitted during normal business hours. See Division 01 Specification Section 01045 "Cutting and Patching" for requirements.

3.2 EQUIPMENT ROUGH INS

A. Verify final locations for rough ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications included in the architectural, mechanical, and electrical specifications for equipment rough in requirements.

3.3 MECHANICAL INSTALLATIONS - HVAC

A. Verify all dimensions by field measurements.

B. Where HVAC systems, materials and equipment are intended for overhead installation, and where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible. Notify the Architect prior to installation of HVAC components when headroom is less than seven (7) feet- six (6) inches and/or where existing system components will be below the new finished ceiling height. Notification shall be through the "RFI" process.

C. Install HVAC systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, identify the conflict and submit and "RFI" for each conflict to the Architect.

D. Install HVAC systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

E. Install HVAC equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

F. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in the Architectural Specifications.

G. Install HVAC systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

H. The contractor shall confirm that all pressure vessels are installed in full compliance with the requirements of the Sate Inspector's Office for Boilers and Pressure Vessels. Refer to "Closeout Procedures" in this Section for additional requirements.

3.4 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Specification Division 01 Section "Cutting and Patching" In addition to the requirements specified in Specification Division 01, the following requirements apply:

1. Patch Materials: Patch finished surfaces and building components using new materials specified for the original installation and using experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.5 CUTTING, WELDING, BURNING

A. Before the contractor and/or any sub-contractor commences any cutting, welding, burning, brazing (pipe sweating), the contractor shall obtain a hot work permit.

B. The hot work permit copy shall remain on the job site at the hot work location until such work is completed at which time the permit shall be returned to the issuing agency.

3.6 PAINTING AND FINISHING

A. Refer to Architectural Specification Section "Painting" for field painting requirements.

B. Damage and Touch Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Do not paint manufacturer's labels or tags.

3.7 CONCRETE BASES

A. Construct concrete equipment bases of dimensions indicated, but not less than four (4) inches (100 mm) larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3,000-psi (20.70MPa), twenty eight (28) day compressive strength concrete and reinforcement bars as specified in the architectural specifications.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

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

3.9 GROUTING

A. Install nonmetallic nonshrink grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms for placement of grout, as required.

D. Avoid air entrapment when placing grout.

E. Place grout to completely fill equipment bases.

F. Place grout on concrete bases to provide a smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's printed instructions.

3.10 PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls and interior waterproof construction.

B. Furnish and install drains, curbs, vent assemblies, sleeves, flashing, etc. specifically designed for application to the particular construction. Install system in accordance with the roofing manufacturer's instructions.

3.11 EXCAVATION AND BACKFILLING

A. General: Perform all necessary excavation and backfilling necessary for the installation of underground HVAC services as part of Division 23 in accordance with the architectural specifications.

3.12 CLEANING AND FINISHES

A. Clean surfaces prior to application of insulation, adhesives, coating, and paint.

B. Provide factory applied finish where specified.

C. Protect all finishes, and restore all finishes to their original condition if damaged as a result of work installed as part of the mechanical specifications.

D. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces.

3.13 LINTELS

A. Lintels shall be provided for openings in masonry, brick, concrete, etc. walls to accommodate work of this division.

1. Lintels shall be provided under this division when not being provided under other divisions. Lintels shall be approved by the Architect.

3.14 ELECTRICAL REQUIREMENTS

A. Unless otherwise indicated, furnish and install control and interlock wiring for the equipment furnished under this division. In general, power wiring and motor starting equipment will be provided as specified in the electrical specifications.

1. Where the electrical requirements of the equipment furnished differ from the provisions made in the electrical specifications, make the necessary allowances as part of the mechanical specifications.

2. Where no electrical provisions are included in the electrical specifications, include all necessary electrical work as part of the mechanical specifications.

B. All electrical work performed as part of the mechanical specifications shall be provided in accordance with the electrical specifications.

3.15 PROVISIONS FOR ACCESS

A. Furnish and install adequate access to all HVAC and plumbing components. The following list shall be used as a guide only:

1. Equipment

2. Valves

3. Dampers and operators

4. Filters

5. Heating and air conditioning units

6. Controls

7. ATC panels

8. Low point drains

B. Access shall be adequate as determined by the Architect.

C. Refer to contract drawings where access panels have been specifically located.

D. Provide additional access panels for adequate access as indicated in paragraph 'A' above.

E. Where access is by means of lift out ceiling tiles or panels mark each access panel using small color coded or numbered tabs. Provide an index chart for identification. Place markers in corner of tile.

3.16 OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing and balancing.

B. Do not operate equipment unless all proper safety devices or controls are operational.

C. Provide all maintenance and service for equipment which is operated during construction.

D. Where specified and otherwise required, provide the services of a manufacturer's factory trained service organization to start the equipment.

3.17 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of equipment and systems to Owner's personnel a minimum two (2) weeks prior to date of final inspection.

1. For equipment requiring seasonal operation, perform instructions for other seasons at the same time.

2. Training period shall be performed within one (1), two (2) week period.

3. Obtain a list of Owner's personnel who will be attending training.

B. Use operation and maintenance manuals and video as basis of instruction. Review contents of manual and video with personnel in detail to explain all aspects of operation and maintenance.

C. Demonstrate the following:

1. Start up.

2. Operation.

3. Control.

4. Adjustment.

5. Trouble shooting.

6. Servicing.

7. Maintenance.

8. Shutdown.

D. Provide at least eight (8) hours straight time instruction to the operating personnel.

1.

2. Time of instruction shall be designated by the Owner.

3. This instruction shall be in addition to instructional requirements of specific equipment specified elsewhere in the mechanical specifications.

4. Record all training sessions. Provide the Owner with three (3) copies of the recordings in digital format.

3.18 LUBRICATION

A. All bearings, motors and all equipment requiring lubrication shall be provided with accessible fittings.

B. Before turning over the equipment to the Owner, the Installer shall provide the following:

1. Fully lubricate each item of equipment.

2. Provide one (1) year's supply of lubricant for each type of lubricant.

3. Provide complete written lubricating instructions, together with diagram locating the points requiring lubrication.

C. Motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal extended grease fittings and drain plugs.

3.19 WALL AND FLOOR PENETRATIONS

A. All penetrations of partitions, walls and floors by ducts, piping or conduit under Specification Division 23 shall be sealed and caulked. Provide UL listed fire stopping systems at penetrations through fire walls as specified in the architectural specifications.

3.20 CONSTRUCTION RECORD DRAWINGS

A. As the work progresses, the contractor shall record on one (1) set of prints, the installed locations, sizes, and depths of pipes, services, equipment, etc. which may differ from the approved contract drawings.

B. Upon completion of the HVAC installations, the installer shall deliver to the Architect construction manager one (1) complete set of marked-up blueprints of the HVAC contract drawings. The construction manager shall compile the mark up prints into a composite set and transmit the set the architect who shall incorporate the mark ups into the record drawing electronic file.

1. The mark-ups shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design.

C. At a minimum include the following installed conditions:

1. Location of all shut off valves, drain valves, and balancing valves with assigned valve tag numbers.

2. Show the location of concealed material and/or equipment requiring service such as strainers, traps, localized A/C units, control valves and/or expansion compensators.

3.21 CLOSEOUT PROCEDURES

A. Operating and Maintenance Instructions: Submit Complete Package At Least Two (2) Months Prior To Substantial Completion. Arrange for each installer of equipment that requires regular maintenance to meet with the Owner's personnel to provide instruction in proper operation and maintenance. If installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items:

1. Maintenance manuals, including a customized list of preventive maintenance items and annual schedule for maintenance.

2. Record documents.

3. Complete inventory of spare parts and materials.

4. Tools.

5. Lubricants.

6. Fuels.

7. Identification systems.

8. Control sequences.

9. Hazards.

10. Cleaning.

11. Warranties and bonds.

12. Maintenance agreements and similar continuing commitments.

B. As part of instruction for operating equipment, demonstrate the following procedures:

1. Start up.

2. Shut down.

3. Emergency operations.

4. Noise and vibration adjustments.

5. Safety procedures.

6. Economy and efficiency adjustments.

7. Effective energy utilization.

3.22 CLEAN UP

A. Excessive debris and dirt, such as occurs from cutting through masonry or plaster walls shall be cleaned up from the equipment and removed immediately after the work of cutting through the walls.

B. Debris shall be removed from the property and properly disposed of.

C. All areas shall be left broom-clean at the end of the work period.

D. Remove all mechanical clipping, wiring, nuts, bolts, etc. left on top of ceilings and ceiling tiles.

3.23 PROJECT PUNCH OUT

A. Architect/Engineer will perform punch out reviews and will provide the Contractor with a list of punch list items to be completed before contract close out. Each and every punch list item shall be initialed and dated by the Contractor when the work is complete. The Architect/ Engineer will not perform any punch list verification until all items have been completed, initialed, dated and the list returned to the Architect/Engineer. If any items have been initialed as being completed by the Contractor and the Architect/Engineer determines that the work is not complete, the Architect/Engineer shall be reimbursed by the Contractor at his regular hourly rate for any and all items requiring revisiting of the site by the Architect/Engineer. Reimbursement shall be made by deducting the Architect/Engineer fee from the Contractor's final payment.

END OF SECTION

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.

2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.

3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

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

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be EC Motors.

B. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

C. Motors 1/20 HP and Smaller: EC motors or shaded-pole type.

D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Grout.
4. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized with plain ends and integral welded waterstop collar.

C. PVC Pipe Sleeves for swimming pool and pool water treatment areas: ASTM D 1785, Schedule 40.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install PVC pipe sleeves and sleeve seal systems for swimming pool and pool water treatment rooms.

B. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

C. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

D. Install sleeves in concrete floors, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
3. Using silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

E. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

F. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Concrete Slabs above Grade:
   a. Stack-sleeve fittings.

2. Interior Partitions:
   a. Steel pipe sleeves/PVC pipe sleeves.

END OF SECTION

SECTION 23 05 18 - ESCUTCHEONS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of cabinets, walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.

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

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

1. Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.

2. Fastener systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements for their preparation.

1. Detail fabrication and assembly of trapeze hangers.

2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

B. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated steel.

2.4 MATERIALS

A. Structural Steel: ASTM A 36, carbon-steel plates, shapes, and bars; galvanized.

B. Stainless Steel: ASTM A 240.

C. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

D. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in the Division 07 specifications for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A 36 carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

G. Install lateral bracing with pipe hangers and supports to prevent swaying.

H. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

I. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

K. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
   b. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

3.3 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.4 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in the Division 09 specifications.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems, and attachments for general service applications.

F. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel attachments for pool mechanical room applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.

4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

6. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    Heavy (MSS Type 33): 3000 lb.

M. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 23 05 48.13 - VIBRATION CONTROLS FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Housed-spring isolators.
3. Spring hangers.
4. Vibration isolation equipment bases.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For testing agency.

C. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

2. Size: Factory or field cut to match requirements of supported equipment.

3. Pad Material: Oil and water resistant with elastomeric properties.

4. Surface Pattern: Waffle pattern.

5. Infused nonwoven cotton or synthetic fibers.

6. Load-bearing metal plates adhered to pads.

7. Sandwich-Core Material: elastomeric.
   a. Surface Pattern: Waffle pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.2 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
   b. Top housing with threaded mounting holes and internal leveling device.

2.3 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

END OF SECTION

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Stencils.
4. Valve tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.

4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

6. Fasteners: Stainless-steel rivets or self-tapping screws.

7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2. Letter Color: White.

3. Background Color: Black.

4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

7. Fasteners: Stainless-steel self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: Size letters according to ASME A13.1 for piping/At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.3 STENCILS

A. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.

2. Stencil Material: Fiberboard or metal.

3. Stencil Paint: Exterior, gloss, alkyd enamel/acrylic enamel. Paint may be in pressurized spray-can form.

4. Identification Paint: Exterior, alkyd enamel/acrylic enamel. Paint may be in pressurized spray-can form.

B. Stencils for Access Panels and Door Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2. Stencil Material: Fiberboard or metal.

3. Stencil Paint: Exterior, gloss, alkyd enamel/acrylic enamel. Paint may be in pressurized spray-can form.

4. Identification Paint: Exterior, alkyd enamel/acrylic enamel. Paint may be in pressurized spray-can form.

2.4 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule with picture frame shall be included in operation and maintenance data and located in the mechanical mezzanine space as indicated by the engineer.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in the Division 09 specifications.

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 30 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Refrigerant Piping: Black letters on a safety-white background.

3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated/self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For supply ducts.

2. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 30 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Colors:
   a. black letters on a safety-white background.

END OF SECTION

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:
   a. Constant-volume air systems.
2. Testing, adjusting, and balancing of equipment.
3. Testing, adjusting, and balancing of existing HVAC systems and equipment.
4. Sound tests.
5. Duct leakage tests verification.
6. HVAC-control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at the Project Site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:
   a. The Contract Documents examination report.

b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Qualifications, Certified by NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

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

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.

2. Strategies and step-by-step procedures for balancing the systems.

3. Instrumentation to be used.

4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:
   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Clean filters are installed.
   d. Fans are operating, free of vibration, and rotating in correct direction.
   e. Variable-frequency controllers' startup is complete and safeties are verified.
   f. Automatic temperature-control systems are operational.
   g. Ceilings are installed.
   h. Windows and doors are installed.
   i. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

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

B. Cut insulation, ducts, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation,"

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

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

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Fans.
3. Energy recovery units.
4. Split system air conditioning units.
5. Ductless split system air conditioning units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

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

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

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

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.

c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.

2. Adjust submain and branch duct volume dampers for specified airflow.

3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.

2. Measure inlets and outlets airflow.

3. Adjust each inlet and outlet for specified airflow.

4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.

2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, speed, volts, amps, and static profile.

4. Mark all final settings.

5. Test system in economizer mode. Verify proper operation and adjust if necessary.

6. Measure and record all operating data.

7. Record final fan-performance data.

3.7 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.

2. Motor horsepower rating.

3. Motor rpm.

4. Phase and hertz.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter size and thermal-protection-element rating.

8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 SOUND TESTS

A. After systems are balanced and Substantial Completion, measure and record sound levels at 3> locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.

2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (L_{eq}).

3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.

4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.

2. Equipment should be operating at design values.

3. Calibrate the sound-testing meter prior to taking measurements.

4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.

5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) and 31.5 Hz to 4000 Hz (RC) with the equipment off.

6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) and 31.5 Hz to 4000 Hz (RC) with the equipment operating.

7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.

8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on Noise Criteria (NC) and Room Criteria (RC) worksheet with equipment on and off.

3.9 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.10 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.

2. Confirm that the sequences of operation are in compliance with Contract Documents.

3. Verify that controllers are calibrated and function as intended.

4. Verify that controller set points are as indicated.

5. Verify the operation of lockout or interlock systems.

6. Verify the operation of valve and damper actuators.

7. Verify that controlled devices are properly installed and connected to correct controller.

8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.

9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.11 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent>. If design value is less than 100 cfm, within 10 cfm.

2. Air Outlets and Inlets: Plus or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.12 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

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

3.13 FINAL REPORT

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

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

3. Certify validity and accuracy of field data.

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

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

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

1. Title page.

2. Name and address of the TAB specialist.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB supervisor who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents, including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.

14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable-frequency controller and Inlet vane settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Duct, outlet, and inlet sizes.
3. Terminal units.
4. Balancing stations.
5. Position of balancing devices.

E. Apparatus-Coil Test Reports:

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

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Refrigerant expansion valve and refrigerant types.
   i. Refrigerant suction pressure in psig.
   j. Refrigerant suction temperature in deg F.

F. Electric-Coil Test Reports: For electric coils installed in terminal variable air volume boxes, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btu/h and kW.
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Airflow rate in cfm.
   i. Face area in sq. ft.
   j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):
   a. Heat output in Btu/h.
   b. Airflow rate in cfm.
   c. Air velocity in fpm.
   d. Entering-air temperature in deg F.
   e. Leaving-air temperature in deg F.
   f. Voltage at each connection.
   g. Amperage for each phase.

G. Fan Test Reports: Series fan powered variable air volume box supply fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan speed.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

H. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

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

I. Instrument Calibration Reports:

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

3.14 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the Architect and Owner.

B. The Architect and Owner shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.

2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.15 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 13 - DUCT INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.

B. All supply, return, and outdoor air ducts and plenum within the building envelope assembly shall be insulated with a minimum of R-8 insulation and installed in compliance with the current IGCC requirements.

C. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

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

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

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

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

4. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

3. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.

3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

4. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.

3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Width: 3 inches (75 mm).

2. Thickness: 11.5 mils (0.29 mm).

3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches (75 mm).

2. Thickness: 6.5 mils (0.16 mm).

3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.8 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, galvanized steel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

1. Comply with requirements in Section 078413 "Penetration Firestopping."

D. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with

insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-

applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply, return, and outdoor air.

2. Indoor, exposed, supply, return, and outdoor air.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

2. Factory-insulated flexible ducts.

3. Factory-insulated plenums and casings.

4. Flexible connectors.

5. Vibration-control devices.

6. Factory-insulated access panels and doors.

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Interior, concealed, supply-air, return-air, and outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 2 inches (50 mm) thick- (MIN. R-8 value) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

B. Interior, exposed, supply-air, return-air, and outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches (50 mm) thick- (MIN. R-8 value) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None

END OF SECTION

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.

2. Refrigerant piping valves and specialties.

3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

a. Filter dryers.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.

2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

3. Show interface and spatial relationships between piping and equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).

2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).

3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) or ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8/A5.8M.

2.3 VALVES AND SPECIALTIES

A. Moisture/Liquid Indicators:

1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.

3. Indicator: Color coded to show moisture content in parts per million (ppm).

4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.

5. End Connections: Socket or flare.

6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

B. Permanent Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell.

2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

3. Desiccant Media: Activated alumina/charcoal.

4. Designed for reverse flow (for heat-pump applications).

5. End Connections: Socket.

6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.

7. Maximum Pressure Loss: 2 psig (14 kPa).

8. Working Pressure Rating: 500 psig (3450 kPa).

9. Maximum Operating Temperature: 240 deg F (116 deg C).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS Retain one or both suction line paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain both paragraphs to require piping larger than NPS 1-1/2 (DN 40) to be different from Type ACR, annealed temper. Delete both paragraphs below if suction lines are part of a heat-pump installation.

A. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

B. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

3.3 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.

3. Install traps and double risers to entrain oil in vertical runs.

4. Liquid lines may be installed level.

L. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

N. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.

2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

E. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).

2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).

3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod, 1/4 inch (6.4 mm).

4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).

5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).

6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).

7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod, 3/8 inch (9.5 mm).

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).

4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

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

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Verify that compressor oil level is correct.

2. Open compressor suction and discharge valves.

3. Check open compressor-motor alignment and verify lubrication for motors and bearings.

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

END OF SECTION

SECTION 23 31 13 - METAL DUCTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Sections:

1. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 31 16 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

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

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

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

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches (914 mm), select joint types in accordance with Figure 2-1.

2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

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

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 (1524) Inches (mm) in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.

2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

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

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.

2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D 3363.

4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

5. Shop-Applied Coating Color: Black.

6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

E. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 DUCT LINER

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

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s)or greater.

7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

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

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 4 inches (102 mm).

3. Sealant: Modified styrene acrylic.

4. Water resistant.

5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Base: Synthetic rubber resin.

3. Solvent: Toluene and heptane.

4. Solids Content: Minimum 60 percent.

5. Shore A Hardness: Minimum 60.

6. Water resistant.

7. Mold and mildew resistant.

8. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.

9. Service: Indoor or outdoor.

10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

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

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

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

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for10-inch wg (2500-Pa) static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

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

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

J. Install fire and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.

2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR DUCTS SERVING HIGH-HUMIDITY LOCATIONS

A. Install ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.

B. Minimize number of transverse seams.

C. Do not locate longitudinal seams on bottom of duct.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2. Outdoor, Supply-Air Ducts: Seal Class A.

3. Outdoor, Exhaust Ducts: Seal Class C.

4. Outdoor, Return-Air Ducts: Seal Class C.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.

6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.

7. Unconditioned Space, Exhaust Ducts: Seal Class C.

8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.

10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.

11. Conditioned Space, Exhaust Ducts: Seal Class B.

12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

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

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in the Division 09 specifications.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual and shall have a rate of air leakage (CL) less than or equal to 4 as determined in accordance with equation 4-8 of the international energy conservation code." Submit a test report for each test.

2. Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.

5. Test for leaks before applying external insulation.

6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by engineer, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports and submit to the engineer for review.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

2. Air Distribution ducts for AHU-1, ERV-1, EF-1,EF-2 and all other exhaust fans except EF-3 (refer to nonmetal duct section): Galvanized sheet steel

B. Supply Ducts:

1. Ducts Connected to AHU-1:
   a. Pressure Class: Positive 3- (750) inch wg (Pa).
   b. Minimum SMACNA Seal Class: B
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to AHU-1:
   a. Pressure Class: Positive or negative 3- (500) inch wg (Pa).
   b. Minimum SMACNA Seal Class: C.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Equipment Not Listed above:

a. Pressure Class: Positive or negative 3 inch wg (Pa).
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 16.
d. SMACNA Leakage Class for Round and Flat Oval: 16.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2- (250) inch wg (Pa).
   b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round and Flat Oval: 16.

2. Ducts Connected to Equipment Not Listed above:
   a. Pressure Class: Positive or negative 3-inch wg (Pa).
   b. Minimum SMACNA Seal Class: B if negative pressure; A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 16.
   d. SMACNA Leakage Class for Round and Flat Oval: 16.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

F. Liner- Provide duct liners for first 10 ft. of all the supply-air and return-air ductwork connected to the AHu :

1. Supply-Air Ducts: Flexible elastomeric, 1 1/2 (38) inch (mm) thick.

2. Return-Air Ducts: Flexible elastomeric, 1 1/2 (38) inch (mm) thick.

3. Return-Air Plenums: Flexible elastomeric, 1 1/2 (38) inch (mm) thick.

4. Transfer Ducts: Flexible elastomeric, 1 (25) inch (mm) thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 1000 fpm (5 m/s) or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
   c. Velocity 1500 fpm (7.6 m/s) or Higher:
      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Standing seam/Welded.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
   c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION

SECTION 23 31 16 - NONMETAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Thermoset FRP ducts and fittings for Chlorine room exhaust-air ducts.

B. Related Requirements:

1. Section 233113 "Metal Ducts" for rectangular and round ducts.

1.3 ACTION SUBMITTALS

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

1. Thermoset FRP duct materials.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevation of top of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated, smoke-rated, and other partitions.
9. Fire and smoke damper locations.
10. Equipment installation based on equipment being used on Project.
11. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

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

1. Duct installation in congested spaces, indicating coordination with general construction, building components, including electrical, plumbing, fire protection, and other building services. Indicate proposed changes to duct layout.

2. Suspended ceiling components.

3. Structural members to which duct will be attached.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:

1. SMACNA's "Thermoset FRP Duct Construction Manual."

2. Static-Pressure Classes:

a. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

2.2 THERMOSET FRP DUCTS AND FITTINGS

A. Duct and Fittings:

1. Thermoset FRP Resin: Comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E 84.

2. Round Duct: ASTM D 2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch (3.2-mm) wall thickness, with tapered bell-and-spigot ends for adhesive joints or with plain ends with couplings.

3. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.

4. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick, flat sheet with fiberglass roving and resin-reinforced joints and seams.

B. Joining Materials: Roving and polyester resin.

C. Fabrication:

1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."

2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Zinc-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

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

E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install duct sections in maximum practical lengths with fewest possible joints.

C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Install ducts with a minimum clearance of 1 inch (25 mm), plus allowance for insulation thickness.

G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

H. Where ducts pass through non-fire-rated interior partitions and exterior walls, and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

I. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

J. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

K. Branch Connections: Use lateral or conical branch connections.

L. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."

3.2 HANGER AND SUPPORT INSTALLATION

A. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 PAINTING

A. Paint interior of thermoset FRP ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, acrylic or latex paint that is chemically compatible with duct material. Confirm compatibility information with paint manufacturer. Oil-based paint is not recommended. Paint materials and application requirements are specified in Section 099123 "Interior Painting."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.

3. Test the total installed exhaust air duct area for each designated pressure class.

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

5. Test for leaks before applying external insulation.

6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

7. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing.

3.6 STARTUP SERVICE

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.7 DUCT SCHEDULE

A. Indoor and Outdoor: Thermoset FRP Ducts and Fittings:

1. Provide suitable external surface protection as recommended by manufacturer.

B. Chlorine Exhaust:

1. Thermoset FRP ducts and fittings.

2. Install exhaust air inlet at 12" above floor.

3. Connect duct to exhaust air fan where indicated on Drawings.

END OF SECTION

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Flange connectors.
4. Turning vanes.
5. Remote damper operators.
6. Duct-mounted access doors.
7. Flexible connectors.
8. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.

b. Manual volume damper installations.

c. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

PART 2 PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).

2. Exposed-Surface Finish: Mill phosphatized.

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

C. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: A scheduled.

C. Maximum System Pressure: 1-inch wg (0.25 kPa).

D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel/0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl, mechanically locked/Neoprene, mechanically locked.

H. Blade Axles:

1. Material: Plated steel/Stainless steel.

2. Diameter: 0.20 inch (5 mm).

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Screen Mounting: Front mounted in sleeve.
   a. Sleeve Thickness: 20 gage (1.0 mm) minimum.
   b. Sleeve Length: 6 inches (152 mm) minimum.

3. Screen Mounting: Rear mounted.

4. Screen Material: Aluminum.

5. Screen Type: Bird.

6. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:

1. Comply with AMCA 500-D testing for damper rating.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

3. Suitable for horizontal or vertical applications.

4. Frames:
   a. Hat shaped.
   b. 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized, roll-formed steel, 0.064 inch (1.62 mm) thick.

6. Blade Axles: Galvanized steel.

7. Bearings:
   a. Oil-impregnated stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Vinyl/Neoprene.

9. Jamb Seals: Cambered stainless steel.

10. Tie Bars and Brackets: Galvanized steel.

11. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

2.5 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.6 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.7 REMOTE DAMPER OPERATORS

A. Description: Cable system designed for remote manual damper adjustment.

B. Tubing: The manufacturer's standard materials

C. Cable: Stainless steel.

D. Wall-Box Mounting: Recessed.

E. Wall-Box Cover-Plate Material: Steel. Paint suitable.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm)] Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges/Continuous and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges/Continuous and two compression latches with outside and inside handles.

2.9 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon steel.

C. Fasteners: Carbon/Stainless steel. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).

E. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.10 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).

2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

E. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).

2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.

3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

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

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at outlet of exhaust fans as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Upstream and downstream from duct filters.

3. At outdoor-air intakes and mixed-air plenums.

4. At drain pans and seals.

5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.

6. At each change in direction and at maximum 50-foot (15-m) spacing.

7. Upstream from turning vanes.

8. Control devices requiring inspection.

9. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

J. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

L. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect terminal units to supply ducts directly. Do not use flexible ducts to change directions.

N. Connect flexible ducts to metal ducts with liquid adhesive plus draw bands.

O. Install duct test holes where required for testing and balancing purposes.

P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Inspect turning vanes for proper and secure installation.
4. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 23 33 46 - FLEXIBLE DUCTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

PART 2 PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.

2. Maximum Air Velocity: 4000 fpm (20 m/s).

3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).

4. Insulation R-Value: Comply with ASHRAE/IES 90.1 with Minimum R6.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Do not use flexible duct to connect VAV terminal units. Do not use flexible duct for elbow connections.

D. Provide metal elbow fittings for supply diffusers and use maximum 60-inch (1500-mm) lengths of flexible duct with metal strip supports.

E. Connect flexible ducts to metal ducts with liquid adhesive plus draw bands.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:

1. Install ducts fully extended.

2. Do not bend ducts across sharp corners.

3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.

4. Avoid contact with metal fixtures, water lines, pipes, or conduits.

5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).

2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.

3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.

END OF SECTION

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ceiling-mounted ventilators.
2. De-stratification fan.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Belts: One set for each belt-driven unit.

1.7 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 PRODUCTS

2.1 CEILING-MOUNTED VENTILATORS

A. Basis of design: model number "SP-VG" manufactured by Greenheck. Other manufacturers meeting all requirements: Acme, Carnes, Lauren Cook Fan Company, Penn Ventilator, and Twin City.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Electronically commutated motor (ECM).

2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

3. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.

4. Isolation: Rubber-in-shear vibration isolators.

5. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

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

B. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design

requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 72 00 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Packaged Energy Recovery Units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

3. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Suspended ceiling components.

2. Floor mounted components.

3. Structural members to which equipment or suspension systems will be attached.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One sets of each type of filter specified.

2. Fan Belts: One set of belts for each belt-driven fan in energy recovery units.

3. Wheel Belts: One set of belts for each heat wheel.

1.7 QUALITY ASSURANCE

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

B. ARI Compliance:

1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."

2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.8 COORDINATION

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

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

C. Coordinate sizes and locations of equipment supports with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

PART 2 - PRODUCTS

2.1 PACKAGED ENERGY RECOVERY UNITS

A. Basis of Design:

1. Basis of design: Model number "HE" manufactured by Renewaire.

2. Other manufacturers: Energy Wall, Greenheck, and Honeywell.

B. Technology

1. The energy recovery system shall be based on a high efficiency fixed plate type energy recovery core with dynamic heat and moisture transfer.

C. Sustainability

1. All materials used in the energy recovery cores shall be natural and 100% recyclable. Use of exotic materials, chemicals, or rare earth elements is unacceptable.

2. The energy recovery cores must be constructed in a sustainable way, producing no hazardous effluent or unrecyclable waste.

D. Energy Recovery Cores

1. The energy recovery cores shall be constructed using an advanced energy transfer membrane capable of transferring both heat and moisture between air streams with at least 70% total efficiency when installed and operated according to the manufacturer's recommendations.

2. The energy transfer membrane shall be made of a specially formulated paper, processed to form a semi-permeable membrane that creates a positive barrier between air streams, while facilitating the transfer of heat and moisture across the membrane.

3. The energy recovery cores shall be made of an energy transfer membrane that is machine folded, with layers separated by a machine folded corrugated net poly-spacer that provides the proper support and separation to the membrane layers, while producing sufficient air turbulence to increase energy transfer efficiency and prevent particulate buildup.

4. The energy recovery core's membrane layers shall be ultrasonically bonded, without the use of chemicals, tapes or adhesives, to form clear air passages.

5. The energy transfer membrane shall be impregnated with Lithium Chloride to actively facilitate the transfer of moisture between air streams and provide microbiocide effect.

6. The energy transfer membrane shall act as a natural microbiocide, actively killing up to 95% of microbes on contact and preventing cross-contamination between air streams. The microbiocide action shall be documented by an appropriate third party testing laboratory. Microbial growth prevention treatments are not sufficient.

7. The energy transfer cores shall be capable of operating from 0° to 140°F, and will be frost- proof down to -40°F, and shall survive temperatures from -40°F to +150°F without damage.

8. The energy recovery cores shall be innumerably washable and rechargeable in salt water without any loss of performance.

9. The housing of the energy recovery cores shall be constructed of a suitable material capable of protecting the energy transfer core and preventing corrosion.

E. Energy Recovery System

1. The energy recovery system shall be constructed of corrosion proof materials, with double wall construction.

2. The energy recovery system shall be capable of any orientation to allow supply and return duct connections to face horizontal, downward, or upward.

3. The energy recovery system shall support the connection of multiple modules with a single connection for each airstream.

4. The energy recovery system shall support the connection of multiple modules with a single connection for controls and high voltage power.

5. The energy recovery system shall consist of single or multiple fixed plate energy recovery cores designed for counter-flow operation within each core. Cross-flow cores are less efficient and are therefore unacceptable.

6. The energy recovery system shall have no moving parts or active seals required for operation, other than bypass dampers.

7. The energy recovery system shall be capable of minimum total efficiencies of 70% when installed and operated in accordance with manufacturer's guidelines and recommendations.

8. The energy recovery media shall demonstrate fire and smoke spread ratings matching UL 900 criteria.

2.2 CONTROLS

A. Unit shall be controlled via a remote mounted unit controller, refer to the sequence of operation for more information.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.

1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Section 23 33 00 "Air Duct Accessories."

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.

C. Install wind restraints according to manufacturers' written instructions.

D. Install units with clearances for service and maintenance.

E. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 CONNECTIONS

A. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

B. Comply with requirements for ductwork specified in Section 23 31 00 "Ductwork."

C. Install electrical devices furnished with units but not factory mounted.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Set initial temperature and humidity set points.
5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

B. Record all training sessions. Provide the Owner with three (3) copies of the recordings in digital format.

END OF SECTION 23 72 00

SECTION 23 81 26 - AIR CONDITIONING UNITS - AIR COOLED, SPLIT SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes: Air-cooled, split-system air-conditioning units

1. Indoor Ceiling Cassette Unit
2. Outdoor Condensing Unit
3. Air-Cooled Split-System Air-Conditioning Unit Controls

1.03 REFERENCES

A. Abbreviations and Acronyms:

1. EER – Energy Efficiency Rating
2. LEV – Local Exhaust Ventilation
3. NEC – National Electrical Code
4. NRTL – Nationally Recognized Testing Laboratory
5. SEER – Seasonal Energy Efficiency Ratio

B. Reference Standards:

1. Air-Conditioning, Heating, & Refrigeration Institute (AHRI):
   a. AHRI 210/240 – Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
   b. AHRI 270 – Sound Performance Rating of Outdoor Unitary Equipment
   c. AHRI 340/360 – Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat-Pump Equipment.
   d. AHRI 365 – Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. ANSI/ASHRAE/IES 90.1-2019 – Energy Standard for Buildings Except Low-Rise Residential Buildings
3. American Society for Testing and Materials (ASTM International):

a. ASTM B280 – Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

b. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

4. Energy Star Criteria (www.energystar.gov)

5. Intertek ETL Certification (ETL)

6. National Fire Protection Association (NFPA):

a. NFPA 70 – National Electrical Code

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

7. Underwriters Laboratories, Inc. (UL)

1.04 SUBMITTALS

A. Product Data and Shop Drawings: Shall meet requirements of Section 01 33 00, Submittal Procedures for Shop Drawings, Product Data, and Samples.

B. Product Data: For each type of product.

1. Submit complete catalog information/product data. Data shall consist of manufacturer's descriptive and technical literature, catalog cuts, performance charts and curves, and installation instructions, including wiring and control diagrams. Identify the model being supplied and all options included.

2. When manufacturer's cutsheets 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. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.

3. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for self-contained air-conditioners.

4. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

5. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

C. Shop Drawings:

1. Include plans, elevations, sections, with mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

4. Include diagrams for power, signal, and control wiring.

D. Certification: Manufacturer's certification that products comply with specified requirements.

E. Start-up test Reports.

F. Operation and Maintenance Manuals.

1.05 CLOSEOUT SUBMITTALS

A. Closeout submittals shall comply with the requirements of Section 01 77 50, Closeout.

B. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: Two (2) set(s) for each air-handling unit.

2. Gaskets: Two (2) set(s) for each access door.

3. Fan Belts: Two (2) set(s) for each air-handling unit fan.

1.07 QUALITY ASSURANCE

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

B. System efficiency shall meet or exceed ANSI/ASHRAE/IES 90.1-2019 criteria or Energy Star Criteria, whichever is more stringent.

C. Air conditioning units shall be Energy Star Certified, if applicable.

D. Air conditioning units shall be UL listed.

E. The units shall be tested by a NRTL and shall bear the ETL label.

F. System efficiency shall meet or exceed 15 SEER when part of a 1:1 (indoor/outdoor) system.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace air conditioning unit(s) and component(s) that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period:

a. Five (5) year(s) from date of Final Acceptance.

b. The compressor shall have a warranty of Seven (7) years from the same date of Final Acceptance.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Safety Requirements: Properly rotating parts to prevent danger to personnel.

B. Design Criteria:

1. Select units in accordance with cooling capacity/requirements and electrical characteristics shown.
2. Provide completely matched combination between evaporator unit and condensing unit.

2.02 DUCTLESS SPLIT HEAT PUMP (AHU-2X & HP-2)

A. General Requirements:

1. In design and purchase of equipment, provide for the interchangeability of items of piping equipment, subassemblies, parts, motors, starters and relays.

2. Air conditioning units shall be UL listed.

3. Air conditioning units shall comply with AHRI 210/240 or AHRI 340/360 or approved equal.

4. Air conditioning units shall comply with AHRI 270 and AHRI 365.

5. Performance Requirements: Shall conform to minimum EER/SEER prescribed by ANSI/ ASHRAE/IES 90.1-2019 when tested in accordance with ARI 340/360 or applicable Energy Star Criteria, whichever is more stringent.

B. Indoor Ceiling Cassette Unit

1. General:

a. The indoor unit shall be factory assembled, wired, and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board, fan, and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an automatic restart function. The indoor unit shall be charged with dry air before shipment from factory.

2. Evaporator Coil

a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.

b. The tubing shall have inner grooves for high efficiency heat exchange.

c. All tube joints shall be brazed with phos-copper or silver alloy.

d. The coils shall be pressure tested at the factory.

3. 2' x 2' size matches size of many ceiling tiles

4. 3D turbo fan enabling increased airflow

5. Airflow Pattern, four-way.

6. Built-in condensate lift up to 33" of lift.

7. Energy saving features

8. Four fan speed: Four fan speed settings including auto-fan
9. Independent Vane Angle Settings: Vane direction shall be changed or fixed from the remote controller to direct the supply air toward or away from objects or occupants in the room. The airflow direction of each vane shall be set using the wired remote controller.

10. Occupancy Detection

11. Ventilation air intake supported

C. Outdoor Condensing Unit:

1. Casing:

a. Weatherproof suitable for outdoor installation.

b. The casing shall be fabricated of galvanized steel, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection. Assembly hardware shall be Type 316 stainless steel for weather resistance.

c. Assembly shall withstand lateral wind gust up to 155 MPH to meet applicable weather codes.

d. Removable panels shall be provided for access to accessories.

e. Units placed outdoors in uncovered areas shall have hail guards, with minimal fasteners for easy removal for access and cleaning.

2. Condenser coils:

a. The outdoor unit coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.

b. The coil shall be protected with an integral guard.

c. Refrigerant flow from the condenser unit to the indoor units shall be independently controlled by means of individual electronic linear expansion valves for each indoor unit.

d. Condenser unit shall be pre-charged with sufficient R454B refrigerant for up to twenty-five (25) feet of refrigerant piping.

e. All refrigerant lines between condenser and indoor units shall be of annealed, refrigeration grade copper tubing, ARC Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1-inch thick insulation shall have a Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E84.

f. All refrigerant connections between condenser and indoor units shall be flare type.

g. Condenser coil capable of total heat rejection based on condensing and ambient temperature shown.

h. Tested at minimum 425 psig.

3. Condenser fan and motor:

a. The unit shall be furnished with a direct drive, high performance propeller type fan.

b. Fans shall be dynamically and statically balanced.

c. The condenser fan motor shall be a variable speed, DC motor and shall have permanently lubricated bearings.

d. Fan speed shall be switched automatically according to the number of operating indoor units and the compressor operating frequency.

e. The fan motor shall be mounted with vibration isolation for quiet operation.

f. The fan shall be provided with a raised guard to prevent contact with moving parts.

g. The outdoor unit shall have horizontal discharge airflow.

h. Motors: Air-conditioning unit manufacturer's standard for intended use and location in accordance with the NEC.

i. Sound rating: Measure in accordance with AHRI 270.

4. Compressor:

a. The compressor shall be a high performance, hermetic, inverter driven, variable speed, dual rotary type, designed for operation with refrigerant R454B. If the listed refrigerant is unavailable for this application, submit an alternative to the Architect and Engineer for approval.

b. The compressor motor shall be DC type, equipped with a factory supplied and installed inverter drive package.

c. The outdoor unit shall be equipped with a suction side refrigerant accumulator.

d. The compressor shall be equipped with an internal thermal overload protector.

5. There shall be no need for line size changes, filters, or sight glasses. Traps shall not be used, and no additional refrigerant oil shall be required.

a. Compressor shall be mounted on internal spring isolator or on rubber-in-shear mounting pads.

b. Three phase powered compressors shall have integral protection for electrical phase loss to prevent damage to compressor.

6. Electrical:

a. The unit shall have the same electrical characteristics as the indoor units.

D. Air-Cooled Split-System Air-Conditioning Unit Controls:

1. Manufacturer supplied factory-wired in separate control cabinet.

2. The control system shall consist of a minimum of one microprocessor on each indoor unit and one in the outdoor unit, communicating via system data over power transmission.

3. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired or wireless controller, providing emergency operation, and controlling the outdoor unit.

4. A 3 conductor AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. If code requires a disconnect mounted near the indoor unit, a 3-Pole Disconnect shall be used – all three conductors must be interrupted.

5. System shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.

6. Shall have a wired remote controller:

   a. Shall be approximately 5-inch b 5-inch with an LCD display.

   b. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Dry/Auto/Fan/Heat mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button.

   c. The controller shall have a built-in temperature sensor. Temperature shall be displayed in degrees Fahrenheit (°F), and Temperature changes shall be by increments of 1-degree F.

   d. Shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet.

   e. Field wiring shall run directly from the indoor unit to the wired controller with no splices. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Up to two (2) wired controllers shall be able to be used to control one unit.

   f. Basic Functions of the remote system are in table below:

Item	Description
Number of Units Controllable	16 units as 1 group
ON/OFF	Run and stop operation
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat
Temperature Setting (Range and modes depend on connected unit model)	Sets the setpoint temperature in the following range: Cool/Dry: 67°F - 87°F Heat: 63°F - 83°F Auto: 67°F - 83°F
Fan Speed Setting (Range and modes depend on connected unit model)	Hi/Mid-2/Mid-1/Low/Auto

Item	Description
Air Flow Direction Setting (Air flow direction settings depend on unit model)	Air flow direction angles 100%-80%-60%-40%, Swing.
Weekly Scheduler	ON/OFF/Temperature setting can be done up to 8 times one day in the week. The time can be set by 1-minute interval.
Operating Conditions Display	Setpoint and room temperature. Sensing can be done at the remote controller or the indoor unit depending on the indoor unit dipswitch setting. Liquid, discharge, indoor and outdoor pipe temperatures. LEV opening pulses, sub cooling and discharge super heat. Compressor Operating Conditions: Running current, frequency, input voltage, On/Off status and operating time.
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed.
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one heat recovery ventilation unit. Heat recovery ventilation items that can be set are "Hi", "Low", and "Stop". Ventilation mode switching is not available.
Auto Lock Out Function	Setting/releasing of simplified locking for remote control buttons can be performed. • Locking of all buttons • Locking of all buttons except ON/OFF button

2.03 DUCTED SPLIT SYSTEM HEAT PUMP (AHU-1 & HP-1)

A. Outdoor unit:

1. The contractor shall furnish and install air-cooled heat pump units as shown as scheduled on the contract documents. Manufacturer must supply hot gas in and out connections for the hot gas to flow to and from the hot gas reheat coil mounted in the air handler for each compressor circuit, two connections for each circuit. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2. APPROVED MANUFACTURERS
   a. Trane.
   b. Aaon.
   c. Daikin.

3. Provide self-contained, packaged, factory-assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressor(s), condensing coil, heat pump reversing valves, and fan(s), integral subcooling circuit(s), filter drier(s), and controls. Provide expansion valve(s) and check valves for split system heat pump unit(s).

4. Performance Ratings: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ANSI/ASHRAE 90.1

5. House components in 18-gauge galvanized steel frame and panels with weather resistant, baked enamel finish. Units surface shall be tested 500 hours in salt spray test.

6. Mount controls in weatherproof panel provided with removable panels and/or access doors with quick opening fasteners.

7. Coils: Microchannel-Parallel flow aluminum tubes that are mechanically brazed to enhanced aluminum fins. Provide subcooling circuit(s). Factory leak test (at supplier), and vacuum dehydrate. Seal with holding charge of nitrogen.

8. Vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Fans shall be statically and dynamically balanced.

9. Weatherproof motors suitable for outdoor use, with permanently lubricated totally enclosed or open construction motors shall be provided and shall have built in current and thermal overload protection. Motors shall be either sleeve or ball bearing type.

10. Compressor(s): Provide direct-drive scroll compressor(s) with centrifugal oil pump providing positive lubrication to moving parts. Motor shall be suction gas-cooled with internal temperature and current sensitive motor overloads. External high and low pressure cutout devices shall be provided.

11. Provide factory-wired condensing units with 24-volt control circuit with internal fusing and control transformers, contactor pressure lugs and/or terminal block for power wiring. Contractor to provide field installed unit mounted disconnect switch. Units shall have single point power connections.

12. Neoprene Isolators: Provide field-installed rubber-in-shear isolators.

13. Condenser Coil guard: Metal grille with Polyvinyl chloride coating to cover condenser coil area.

14. Condenser shall include hot gas lines to and from the unit piped to the outside of the cabinet labeled for hot gas reheat hookup.

B. Indoor Units

1. Completely factory assembled, Convertible for vertical configuration, Convertible for heat pump application, Convertible for left or right external connections (refrigerant and/or electrical), Convertible for front or bottom air return, Nitrogen holding charge, and Certified to UL60335-2-40 for indoor blower coil units.

2. Casing shall consist of Zinc coated, heavy gauge, galvanized steel Weather resistant baked enamel finish. Access panels with captive screws, Completely insulated with foil faced, cleanable, fire retardant, permanent, odorless glass fiber material, Captured or sealed

insulation edges, Electrical connection bushings or plugs, Refrigerant connection bushings or plugs, and Withstand elevated internal static pressure.

3. Evaporator Coil shall be 3/8-inch internally enhanced copper tube mechanically bonded to lanced aluminum plate fins, Factory pressure and leak tested to 449 psig., Draw-through airflow

4. Dual circuits are interlaced/intertwined, Double sloped, removable, cleanable, composite drain pan, Four drain pan positions.

5. Indoor Fan includes Double inlet, double width, forward curved, centrifugal type fan, Adjustable belt drive, Permanently lubricated bearings.

6. Indoor Motor will include Fixed motor sheaves (Single Zone VAV), Thermal overload protection, Permanently lubricated bearings, Meet energy policy of 1992 (EPACT).

7. Controls shall be Completely internally wired, Colored and keyed connectors, colored wires, Magnetic indoor fan contactor, Detachable low voltage connectors, Single point power entry, Evaporator defrost control.

8. Filters shall be Access from side coil panels, Filters slide on rack, Filter rack convertible to two inch (2-inch) capability on 5 to 10 ton units.

9. Leak detection system.

10. Single Zone Variable Air Volume, Variable Frequency Drive (VFD), Motor soft start — avoids start up belt noise and increases belt life, Programmable VFD keypad accessible outside of airstream, Airflow adjustment via display/keypad.

11. For control requirements, refer to the sequence of operation on drawing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Fit equipment and appurtenances within space provided and make readily serviceable. Provide access space around air conditioning units for service as indicated, and maintain installation recommendations of manufacturer.

B. Install equipment as recommended by manufacturer and as indicated on design drawings, in compliance with Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.

C. Provide foundation, platforms and hangers necessary for proper installation of equipment.

D. Install outdoor equipment on concrete pads if applicable, a minimum of four (4) inches in height.

E. Ensure fans operate without noticeable vibration after installation.

F. Charge refrigerant in accordance with manufacturer's recommendations.

G. Electrical connections: Section 26 05 19 and Section 26 05 33.

H. Install unit in accordance with NFPA 90A.

3.02 FIELD QUALITY CONTROL

A. Test and inspect air conditioning units, components, assemblies, and installations. Testing and inspections shall be witnessed by the Architect and Owner.

B. Operational Test:

1. Test unit after installation to demonstrate that all components are functioning properly, that noise level meets criteria as shown, and that the manufacturers stated heating and cooling capacities are achieved.

C. Furnish necessary equipment, perform required tests and submit certified reports. Test the following:

1. Air conditioning and heat pump unit.

a. Circuit for connections in accordance with wiring diagrams.

b. Equipment enclosures for continuity to the grounding system.

c. Operations of circuits, operating each control 3 times minimum.

2. Leak testing:

a. Refrigerant piping:

1) Use electronic leak detector to check leaks after soap-bubble test.

D. Prepare test and inspection reports identifying the air conditioning units and components have been installed, tested and inspected as above, with legible printed names and badge/contractor number, signed and dated, by both the contractor and manufacturer's representative who witnessed the tests and inspections.

3.03 ADJUSTING

A. Comply with requirements in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.04 CLEANING

A. After completing system installation, testing, adjusting, and balancing unit, and after completing startup service, clean units internally and remove foreign material, construction dirt, and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings; install new, clean filters.

B. Clean the site and all applicable improvements as specified in Section 01 74 00, Cleaning and Waste Management.

C. Before fan or filter is operated, clean inside of air system, including casing, fan, etc., used for air supply or return.

D. Clean with use of industrial vacuum cleaners to effectively remove dust and foreign material from surfaces swept by air stream.

E. Clean equipment exterior and interior and leave in satisfactory condition, free of grease and oil.

3.05 TRAINING

A. Train Authority maintenance personnel to adjust, operate, and maintain units for minimum of 4 hours.

END OF SECTION

SECTION 26 00 10 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 GENERAL REQUIREMENTS

A. The requirements indicated in this specification section shall apply to all electrical work.

B. Equipment: All electrical equipment, including but not limited to, wiring devices, wiring materials and electrical construction materials shall be new and of the highest quality and latest improved design.

C. Workmanship: Workmanship shall be of the highest grade and all installation work shall be performed by thoroughly qualified mechanics of the appropriate trade. All equipment shall be installed and connected in accordance with the best engineering practice. Manufacturer's instructions and recommendations shall be followed and all electric connections shall be provided.

D. Completeness: The Contractor shall furnish and install all labor, materials, tools, equipment, programming, software, startup, licenses, and services as required to make all equipment complete and fully operational. Provide all required mounting hangers, supports, hardware and accessories to install all equipment and devices. Make all equipment and devices complete and fully operational.

E. Drawings: The drawings showing the layout of the electrical system indicate approximate locations of outlets, apparatus and equipment. The runs of feeders and branches as shown, the drawings are schematic only and are not intended to show the exact routing and location of conduits and conduit terminations. The final determination as to routing, location and termination shall be governed by structural conditions, obstructions and job conditions. This shall not be construed to mean that the design of the system may be changed without the written approval of the Engineer; it merely refers to the exact run of raceways and the exact placement of outlets, etc. It shall be the Contractor's responsibility to obtain all shop drawings affecting conduit terminations to the equipment specified in this or other sections or furnished by others, and to verify conduit locations before installation. The Contractor shall consult all contract drawings and specifications which may affect the location of any outlet, equipment or conduit run, to avoid improper locations of such items and to avoid interference with other trades.

F. Accessibility: Electrical equipment such as junction and pull boxes, panelboards, switches, controls, and other apparatus that may require maintenance or operation from time to time, shall be made easily accessible. Although the equipment may be shown on the drawings in certain locations, in the course of building construction, it may develop that such locations do not afford proper accessibility, in which case the Contractor shall direct the Engineer's attention to the condition before advancing the construction.

G. Site examinations: All bidders, prior to submitting a bid, shall thoroughly acquaint themselves with the conditions under which the work will be performed. No allowance shall be made subsequently in connection with this, for any error or negligence on the contractor's part.

H. Unless noted as "EXISTING", "BY OTHERS" or "NIC", all work, devices and equipment are new and shall be furnished and installed by the contractor.

I. The contractor shall comply with all the requirements indicated in the contract documents. The contractor shall provide all the items indicated in the contract documents, without any additional cost or time extension, regardless of whether or not the item is a special order, the item is in short supply, the item has a minimum quantity order requirement, the item has a long lead time, and/or the item has additional/non-standard costs associated with it. The contractor shall coordinate with the manufacturer and supplier of the item prior to submitting a bid.

J. Where there is a conflict in the Contract Documents, contact the owner and the engineer immediately. The owner and the engineer will provide further direction. For pricing and bidding purposes, the more stringent or higher quality requirement shall be used. All work shall comply with all applicable codes, and shall be inspected and approved by the Authority Having Jurisdiction.

K. Furnish and install devices and equipment in accordance with the NEC, the manufacturer's recommendations, and the contract documents.

L. All devices and equipment shall be suitable for its intended use, environment, and location in the accordance with the NEC, UL, the manufacturer's recommendations and the contract documents.

M. All work shall be coordinated with the electrical contractor.

N. Wire lugs, connectors and splices shall be UL Listed and shall be compatible with the wire size/material/type. Coordinate equipment and wiring to ensure that they are compatible with each other.

O. The following applies to circuits rated 600V or less:
   1. For circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, the equipment shall be listed and identified for use with 75 degrees C conductors, unless otherwise noted.

P. The ABBREVIATIONS indicated in the electrical drawings shall also apply to the abbreviations used in the electrical specifications, unless otherwise noted.

Q. Exact location of electrical receptacles/floor boxes and/or electrical connections to equipment shall be coordinated with the exact location of items in the field (including, but not limited to, the following: exact location of cabinets/backsplashes/countertops/electrified systems furniture associated with the receptacles/floor boxes, exact locations of equipment, etc.); and, shall be coordinated with the exact location of wire terminals at the equipment (which shall be based on the wiring diagrams of the equipment, the installation manuals of the equipment, and/or coordination with the manufacturer). Coordination shall take place prior to starting any work.

R. Wet Locations:
   1. The following areas shall be considered Wet Locations and shall be provided with equipment/materials that are suitable for Wet Locations in accordance with the NEC and the contract documents:
      a. All outdoor or exterior locations
      b. From the elevator pit floor up to 48" above the floor, inside the elevator hoistway

2. Hangers, supports, raceways, boxes, and other equipment/materials shall be suitable for use in Wet Locations in accordance with the NEC and the contract documents.

S. Do not exceed the maximum wire pulling tension recommended by the wire manufacturer. Coordinate with the wire manufacturer as required. Pull wire through handholes, manholes, and other underground structures in a manner that shall minimize the pulling tension on the wire.

T. Prior to installing the equipment, the contractor shall field survey and verify the exact locations where the equipment are being installed, and shall notify the engineer immediately if there are any issues or conflicts. Also, prior to installing the equipment, the contractor shall coordinate the exact location of the equipment with the engineer, whether or not there are any issues or conflicts. Prior to installing the equipment, the contractor shall adjust the exact locations of the equipment, in accordance with the direction provided by the engineer. The contractor's bid price shall include adjusting the exact locations of the equipment up to 12 feet away (within the same room) from the locations indicated in the plan drawings.

U. Mounting heights indicated in the Contract Documents are measured from the finished floor or finished grade to the bottom of the equipment, unless otherwise noted.

V. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

W. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

X. Provide touch up paint as required on equipment finishes that have been scratched, and provide touch up paint as directed by the Engineer. Touch up paint shall be provided in accordance with the manufacturer's recommendations. Do not allow paint to come in contact with conductors, insulation or any live parts. All nameplates and labels shall remain visible and legible.

Y. Unless the context otherwise requires, a reference to one gender shall include reference to the other genders. For example, the word "his" shall be interpreted to include both the masculine and feminine genders.

Z. Where there are space heating equipment located adjacent to electrical equipment (including but not limited to, infrared unit heaters, electric/gas fired unit heaters, etc), the contractor shall coordinate with the manufacturer of the space heating equipment, get the installation manuals for the space heating equipment, and determine the clearance requirements around the space heating equipment. The contractor shall comply with the clearance requirements of the manufacturer, and shall not install any electrical equipment/wiring/conduit within the clearance area. Additionally, all electrical equipment/wiring/conduit shall be provided with appropriate clearance from space heating equipment, so that their maximum operating temperature, and/or temperature rating, is not exceeded.

AA. Service equipment shall be UL labeled for use as service equipment. Provide grounding and bonding of service equipment in accordance with NEC requirements.

BB. Inside a sally port, storage room, trash room, garage, and rooms which can be entered by vehicles, keep the space directly in front of the exterior door (overhead door, rollup door, swing door, etc.) clear of all electrical items. The volume of the clear space shall not be less than the following:

1. Volume of clear space = width of the exterior door opening x height of the exterior door opening x distance from the exterior door to the opposite wall

CC. Where the contract documents specifies a product name, model, or manufacturer, and this product has been discontinued or is no longer in production, the contractor shall provide a product from the same manufacturer, that meets the requirements indicated in the contract documents, at no additional cost to the owner. The product provided by the contractor shall be an approved equal of the specified product. Also, the contractor shall provide a written statement from the specified manufacturer, indicating that the specified product has been discontinued or is no longer in production. All products shall be submitted for review and approval by the design team.

DD. Where equipment is located on the roof, and the contract documents require that the equipment be mounted a certain height "above the finished floor", "above the finished floor" shall mean "above the roof".

EE. The contractor shall core drill holes in exiting concrete walls, ceilings, and floors as required for the installation of wiring and conduit. The contractor shall use ground penetrating radar to scan the concrete for any obstructions and/or structural elements/components prior to core drilling. Core drilling shall be made only at locations which are free of obstructions and/or structural elements/components. Do not drill, cut, or damage beams, joists, trusses, and other load bearing structures. All work shall be reviewed and approved by the owner, the architect, the structural engineer, and the Authorities Having Jurisdiction.

FF. Prior to installing equipment and prior to closing up the walls/ceilings, the contractor shall have 2 on-site meetings with the owner on separate days, lasting 8 hours on each day, to coordinate exact locations of equipment associated with the systems listed below. The contractor's bid price shall include adjusting the exact locations of the equipment up to 12 feet away (within the same room) from the locations indicated in the plan drawings.

1. Telecommunications system
2. Public address system
3. Intercom system
4. Audio-visual system
5. Access control system
6. Intrusion detection system
7. CCTV system
8. Sound Reinforcement System

1.3 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies: Comply with electrical construction code requirements of State, City and such other local political subdivision specifications as may exceed the requirements of national codes, standards and approving bodies.

B. All electrical equipment installed under this contract shall bear UL label. Equipment shall be installed in accordance with the requirements of UL and the manufacturer.

C. Comply with the National Electrical Code.

D. Certificates and Permits: Upon completion of work, and prior to final payment, furnish to the Engineer formal certification of final inspections from authorities having jurisdiction and secure required permits or certificates (if any) from such authorities. Additionally, prepare detailed diagrams and drawings which may be required by those authorities having jurisdiction. All the cost for obtaining certificates and permits will be paid by the Contractor.

E. Furnish and install equipment in accordance with the manufacturer's recommendations and the applicable codes.

1.4 REFERENCES AND DEFINITIONS

A. Basic References: The following codes, standards, and approvals as referenced throughout the drawings and specifications, shall serve as the minimum standards and quality requirements directly appropriate to the work and workmanship. References to catalogs, standards, codes, specifications and recommendations, etc., means latest edition of such publications in effect at the date of invitation to submit bid.

1. American National Standards Institute (ANSI): ANSI C2; National Electrical Safety Code
2. National Electric Manufacturer's Association (NEMA) Standards as apply to specified Products.
3. National Fire Protection Association (NFPA): NFPA 70 (National Electrical Code), NFPA 72 (National Fire Alarm Code), NFPA 70E (Standard for Electrical Safety Requirements for Employee Workplaces), and other applicable NFPA codes
4. Underwriters' Laboratories, Inc. (UL) Listings, Labels, and Approvals shall govern the quality and performance of specified Products.
5. Americans with Disabilites Act (ADA)
6. Institute of Electrical and Electronics Engineers, Inc (IEEE)
7. National Electrical Contractor's Association (NECA)
8. International Electrical Testing Association (NETA)
9. Occupational Safety and Health Administration (OSHA)
10. Code of Maryland Regulations (COMAR)

B. Definitions:

1. "Provide" - means "furnish and install"
2. "Indicated" - means "indicated in contract documents"
3. "Concealed" - means items referred to are hidden from normal sight, this includes items partly excavated or crawl spaces and in service tunnels used solely for repairs and maintenance
4. "Exposed" - means items are not "concealed"
5. "Feeder" - means "All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device"
6. "Feeder circuit breakers" - means circuit breakers protecting feeders.
7. NETA ATS - International Electrical Testing Association Acceptance Testing Specifications, Latest Edition
8. "Building" – A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors
9. "degrees C" – means "degrees Celsius"
10. "degrees F" – means "degrees Fahrenheit"
11. "homerun" – This word shall refer to that portion of the electrical circuit wiring and conduit between the circuit breaker or fuse protecting the electrical circuit, and the first equipment or load on the electric circuit. There is no other equipment or load on the electrical circuit between the first equipment or load, and the circuit breaker or fuse. For example, a 120V, 20A circuit breaker feeds #12 AWG wiring which connects to 3 – NEMA 5-20R receptacles. The wiring and conduit that runs from the circuit breaker to the 1st receptacle is considered the homerun wiring and conduit. There is no other receptacle on the electrical circuit between the 1st receptacle and the circuit breaker.
12. "Branch circuit" – means "The circuit conductors between the final overcurrent device protecting the circuit and the outlets(s)."

13. "Suspended ceiling" – Suspended ceiling (sometimes referred to as dropped ceiling or false ceiling) is a secondary ceiling suspended or supported from the building structure above, creating a void between the underside of the building structure and the top of the suspended ceiling. Suspended ceilings include, but are not limited to, grid type ceilings, gypsum board ceilings, drywall type ceilings, and other ceilings which are located below the building structure. Suspended ceilings are either accessible ceilings (including, but not limited to, grid type ceilings with removable ceiling panels or tiles) or non-accessible ceilings (including, but not limited to, gypsum board ceilings and drywall type ceilings).
14. "Equipment" shall include, but not be limited to, fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.
15. "Smoke duct detector" and "duct smoke detector" shall have the same meaning. Both terms shall mean smoke detectors which are used to detect smoke in HVAC (Heating, Ventilation, and Air Conditioning) ducts.
16. "Breaker" – means "circuit breaker"

1.5 SUBMITTALS

A. Product Data: Submit Product Data applicable to items listed under Submittals in each individual Specification Section; and such items as may be indicated on the Drawings.

B. Coordination Drawings:

1. Where the contract documents require coordination drawings; or, where the contractor has any question or request-for-information that relates to locations of equipment, or coordination of equipment locations, the contractor shall provide a coordination drawing. The coordination drawing shall have reflected ceiling plans, structural plans, floor plans and other relevant drawings, drawn to scale on one drawing, on which the following items are shown and coordinated with each other, based on actual dimensions of the items, input from actual installer of the items involved, and existing conditions (the contractor shall field measure all existing conditions):

    a. Routing of underground ducts or ductbanks.
    b. Routing of conduit encased in concrete slab.
    c. Routing of electrical wiring/conduit
    d. Structural beams, trusses and columns.
    e. Motors and all other mechanical equipment.
    f. Mechanical pipes and ducts
    g. Junction/pull boxes and electrical enclosures
    h. Electrical Distribution Equipment (switchgear, transformers, motor control centers, panelboards, switchboards, etc.)
    i. All equipment/devices which are relevant to the question or request-for-information

C. Shop Drawings

1. General: The Contractor shall submit to the Engineer for approval, before fabrication, detailed shop drawings for all electrical equipment and materials.
2. Shop drawings shall clearly indicate, using arrows and/or highlighting on all copies, which items are being submitted and that each item being submitted is in compliance with all requirements on the drawings and in these specifications. All pertinent specification and drawing requirements shall be indicated on the manufacturer's drawings. Complete model number of equipment shall be indicated.
3. Shop drawing shall include a cover sheet that indicates the project name, the name of the contractor, and the name of the supplier/distributer.

4. Shop drawing shall have a summary page that indicates the following: quantities of all equipment, manufacturer/model number for all equipment, and lead time for all equipment.
5. Shop drawings of related equipment shall be submitted together.

D. "As-Built" Drawings:

1. The contractor shall provide "as-built" drawings, in both electronic and hardcopy formats. The contractor shall provide accurate project record drawings, showing in red color on the working drawings and electrical drawings, all changes, modifications, and alterations from the original drawings, made during installation of the work. Upon completion of the work, the contractor shall provide the Owner with a USB drive that has an electronic copy of the project record drawings, and a full size hardcopy of the project record drawings.

E. Operating and Maintenance Manuals

1. General: Upon completion of the work, the Contractor shall furnish Operating and Maintenance Manuals for use by the Owner. The manuals shall include operating and maintenance information on all systems and items of equipment. The data shall consist of catalogs, brochures, bulletins, charts, schedules and drawings describing location, operation, maintenance, lubrication, operating weight and other information necessary for the Owner to establish an effective operating and maintenance program.
2. Shop Drawings: Copies of appropriate shop drawings shall be included in the Operating and Maintenance Manuals. The requirements for manuals is a separate contractual item and in no way supersedes the requirements for shop drawings and vice-versa.
3. Approval: Completed manuals shall be submitted to the Engineer for review and approval. Incomplete or inadequate manuals will be returned to the Contractor for correction and resubmission.
4. Provide an electronic copy (PDF format) on 3 USB drives, and 3 hardcopies in 3-ring binders, of all operating and maintenance manuals, unless a greater quantity is specified elsewhere in the contract documents, in which case the greater quantity shall apply. Each drive and each hardcopy shall have all the operating and maintenance manuals for all the equipment.
5. Equipment keys and passwords shall be provided to the Owner's authorized representative or representatives. A document shall be provided indicating who received the keys and what are the passwords. Document shall be neat and typewritten.
6. Provide a separate section in the O&M Manuals for maintenance testing schedules of all equipment. A factory authorized representative of the equipment manufacturer shall certify the maintenance program. Include calendar schedule in table format to indicate all maintenance actions included during the warranty period with spaces for future testing.
7. All factory and field test reports by the contractor, manufacturer, and/or independent testing company shall be included in the O&M Manuals.
8. Wiring diagrams for all factory and field wiring shall be included in the O&M Manuals.

F. Spare Parts and Accessories List

1. A complete list of spare parts and accessories for equipment shall be provided.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials and equipment to the Project site in a clean condition with openings plugged or capped (or otherwise sealed by packaging) both during shipping and during temporary storage.

B. Delivered electrical equipment crating and/or packaging shall clearly identify pick-points or lift-points. In the absence of crating or packaging, pick-points or lift-points must be identified on the equipment.

C. When unloading materials and equipment provide special lifting harness or apparatus as may be required by manufacturers. Handle materials and equipment in accordance with manufacturer's written instructions.

D. The Contractor shall determine the required equipment needed for unloading operations and have such equipment on site to perform unloading work on the date of equipment delivery.

E. Store materials and equipment, both on and off site, in accordance with manufacturer's written instructions. Keep equipment in a dry location.

1. Temporary Heating: Apply temporary heat to materials and equipment, according to manufacturer's written instructions, throughout periods when environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

1.7 WARRANTY

A. The Contractor shall guarantee that all work performed, and all materials/equipment installed by him, are free from defects. The Contractor shall repair or replace any defective equipment, materials or workmanship, free of cost to the Owner, for a period of two (2) years from the date of final acceptance of the Contractor's work. The date of final acceptance is determined by the Owner. Where individual specification sections indicate a Warranty period longer than two (2) years, the longer warranty period shall apply.

B. During this warranty period the Contractor shall:

1. Correct and make good all electrical defects. Faulty equipment and materials shall be repaired or replaced as required to produce satisfactory results as directed by the engineer and without additional cost to the Owner. Contractor shall provide service within 24 hours after the call has been made by the Owner.

1.8 DAMAGE TO OTHER WORK

A. Damage: Cutting or damage to existing structures, surfaces or installations shall be repaired at the expense of the Contractor. All such repairs or patching shall be neatly done by mechanics of the appropriate trade, and shall be done in such a fashion as to leave no readily apparent joint or change in appearance, and to leave no structural or other weakness.

1.9 TEMPORARY POWER

A. Contractor shall be entirely responsible for temporary power. The contractor shall provide temporary generators and temporary electrical equipment as required. The contractor shall apply for temporary electrical service from the utility as required. All applications, fees, temporary connections, etc. shall be made by the contractor.

B. The contractor shall provide wiring, conduit, connections, supports, and equipment as required to start/run the temporary power system, and keep it fully operational. All work shall comply with the NEC and the applicable codes.

C. Where temporary generators are provided, the contractor shall comply with the following:
   1. The contractor shall monitor the temporary generator and the associated power distribution equipment remotely for low fuel level, alarms, and faults; and, shall provide all wireless communications equipment required for monitoring.
   2. The contractor shall make sure that the generator has sufficient fuel, and is fully operational. The contractor shall refuel the generator as required.

1.10 COORDINATION

A. General: The Contractor shall coordinate the work performed and equipment furnished by the Electrical Contractor with work performed and equipment furnished by other trades to ensure a complete and satisfactory installation.

B. For all site work, comply with all the requirements of the state or local jurisdiction which apply to locating existing utilities. The requirements in Maryland include, but are not limited to, contacting "Miss Utility" prior to starting any site work.

1.11 INTERRUPTION OF ELECTRIC SERVICE

A. Do not interrupt electric, data, telephone, and/or cable tv services to facilities occupied by the owner or others, unless permitted under the following conditions, and then only after arranging to provide temporary electric, data, telephone and/or cable tv services, according to requirements indicated:

   1. Notify the owner no fewer than 14 days in advance of proposed interruption of electric, data, telephone, and/or cable tv services.
   2. Do not proceed with interruption of electric, data, telephone, and/or cable tv services without the owner's written permission.

1.12 CONTRACTOR'S CERTIFICATION

A. The Contractor shall submit a signed and dated letter to the owner and the engineer certifying the following:
   1. He shall certify that all work has been performed in accordance with the contract documents (including, but not limited to: any amendments, addendums, and contract modifications) ;
   2. He shall certify that all work has been inspected and approved by the Authorities Having Jurisdiction; AND,
   3. He shall certify that all work has been performed in accordance with the National Electrical Code and all applicable codes.

1.13 ELECTRICAL WORK FOR MECHANICAL AND PLUMBING EQUIPMENT

A. Additional HVAC (Heating, Ventilation, and Air Conditioning) and Plumbing circuits/wiring are indicated in the mechanical/plumbing drawings and specifications. The electrical contractor shall coordinate with the mechanical/plumbing contractor to make sure that all the circuits/wiring required in order to make the HVAC/Plumbing system complete and fully operational are included in the bid price. All HVAC/Plumbing circuits/wiring shall be provided in accordance with the NEC and the Contract Documents. Wiring shown in the mechanical/plumbing drawings and specifications include, but are not limited to: wiring for dampers, thermostats, and other HVAC/Plumbing power/controls.

B. Prior to submitting a bid or a price proposal, coordinate with the mechanical/plumbing contractor. Get wiring diagrams, cut sheets, installation/operation manuals, and other information regarding the equipment.

C. Coordinate exact location and quantities of equipment with the mechanical/plumbing contractor.

D. Provide wiring, conduit, mounting supports, hardware, and accessories (including, but not limited to: control switches, push buttons, safety devices, disconnects, starters, audio/visual indicators, interlocks, limit switches, remote stations, detector devices, etc) as required for a complete, fully operational, and code compliant system.

E. All work shall comply with the manufacturer's recommendations and NEC requirements.

1.14 ELECTRICAL WORK FOR MISCELLANEOUS EQUIPMENT

A. For all equipment that require electrical connections, provide wiring, conduit, and equipment accessories (including, but not limited to: control switches, push buttons, safety devices, disconnects, starters, audio/visual indicators, interlocks, limit switches, remote stations, detector devices, sensors, controls, speakers, audio/visual devices, level/pressure instruments, power supplies, etc.) as required for a complete and fully operational, and code compliant system. The equipment accessories are specified in the contract documents (including, but not limited to, drawings and specifications) associated with each equipment. For example, where there are overhead doors, the accessories associated with the overhead doors are indicated in the overhead door specifications.

B. Prior to submitting a bid or a price proposal, coordinate with the contractor that is furnishing the miscellaneous equipment. Get wiring diagrams, cut sheets, installation/operation manuals, and other information regarding the equipment.

C. Coordinate exact location and quantities of miscellaneous equipment with the contractor that is furnishing the miscellaneous equipment.

D. All work shall comply with the manufacturer's recommendations and NEC requirements.

1.15 TRACER WIRE

A. Provide tracer wire for underground civil and/or plumbing utilities in accordance with State, Local Jurisdiction, and/or Utility requirements. All work shall comply with the NEC, and State/Local Jurisdiction/Utility requirements. Coordinate with Civil and/or Plumbing drawings/specifications/contractors.

1.16 TRAINING

A. Provide training for all equipment. Schedule training with at least 21 days advance notice, to the owner and engineer, by submitting a draft training schedule. Indicate all proposed training dates with specific equipment descriptions. The Contractor shall then confirm these dates with the owner and engineer. After receiving approval of these dates, the Contractor shall submit a final training schedule at least 14 days prior to the agreed upon dates.

B. All training shall be done hands-on, on-site, and in-person, on the actual equipment installed in the field.

C. The training instructor shall be factory trained by the manufacturer of the equipment. The qualifications of the training instructor shall be submitted for review/approval.

D. An attendance sheet shall be provided by the contractor during the training days. The attendance sheet shall be signed by all participants of the training, and the training instructor. The attendance sheet shall be submitted for record.

E. Provide a minimum of 4 hours of training for each equipment. Where individual specification sections indicate a training period longer than 4 hours, the longer training period shall apply.

F. Provide a video recording of all demonstration and training. The demonstration and training video shall be saved onto portable external hard drives. 3 sets of portable external hard drives shall be provided to the owner.

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION

SECTION 26 02 00 - ELECTRICAL TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:

1. Qualifications of testing agencies and their personnel.
2. Suitability of test equipment.
3. Calibration of test instruments.
4. Coordination requirements for testing and inspecting.
5. Reporting requirements for testing and inspecting.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: As specified in each Section containing electrical testing requirements and in subparagraph and associated subparagraph below.

1. Independent Testing Agencies: Independent of manufacturers, suppliers, and installers of components to be tested or inspected.

a. Testing Agency's Field Supervisor for Power Component Testing: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Division 26 Specification Sections.

B. Test Equipment Suitability: Comply with NETA ATS

C. Test Equipment Calibration: Comply with NETA ATS

1.4 SUBMITTALS:

A. Provide qualification data for testing agency. Qualification data shall include: corporate history and corporate resume, key personnel and project supervisor resumes, 10 similar projects with scope descriptions, 5 similar testing project reference names and contact information, copy of all certifications, samples of all test report sheets, and corporate safety procedures manual.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 TESTS AND INSPECTIONS

A. See individual Specification Sections for Tests and Inspections required on Electrical Systems.

B. In addition to the requirements indicated in each individual Specification Section, comply with all of the following:
   1. Provide a Test Report for each test that indicates the following:
      a. Test procedures used.
      b. Test results that comply with requirements.
      c. Test results that do not comply with requirements, and recommended corrective actions which need to be taken in order to achieve compliance with requirements.
   2. At the beginning of each test report, provide an executive summary that indicates whether each equipment has PASSED all the specified tests or FAILED one or more tests. Where the equipment has failed, the summary shall indicate each test that FAILED. Where the equipment has failed, the summary shall provide a recommendation for corrective action.
   3. Remove and replace malfunctioning equipment and test new equipment at no additional cost to the owner. Submit test reports.
   4. Where a Test Report uses a specific name/label/designation for a particular equipment, that name/label/designation shall be consistent with the name/label/designation indicated in the Contract Documents and in the field.
   5. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.

END OF SECTION

SECTION 26 04 20 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:

1. Across-the-line, manual and magnetic controllers.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each enclosed controller.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Nameplate legends.

c. Short-circuit current rating of integrated unit.

d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. Include the following:

1. Routine maintenance requirements for enclosed controllers and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

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

C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.6 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."

1. Bimetallic Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have

heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. Provide fuses in the primary, and in the secondary of the control power transformer. Primary and secondary fuses shall be sized in accordance with the manufacturer's recommendations and NEC requirements. Additionally, the secondary fuse rating shall not exceed 7 amperes. Where the load on the secondary of the control power transformer necessitates a fuse rating greater than 7 amperes, provide multiple control power transformers so that the 7 ampere fuse rating is not exceeded.

2. Solid State Overload Relay: Relay shall have the following features:

a. Fault protection for the following: overload and phase loss.

C. Combination Magnetic Controller (also called "Combination Starter" in the contract documents): Factory-assembled combination controller and disconnect switch.

1. Disconnecting Means: NEMA KS 1, heavy-duty, non-fusible (unless otherwise noted) switch.

a. Where fusible type disconnecting means are specified, the fuses shall be Class R type. Short circuit rating of fusible magnetic controllers when used with Class R fuses shall not be less than 100,000A.

2. Provisions for padlocks: Disconnecting means shall include provisions for being padlocked in the open or closed position.

2.3 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location. See drawings for NEMA 250 enclosure type.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights (LED type, push-to-test), and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Control Relays: Auxiliary and adjustable time-delay relays.

D. Equipment Ground Kit: Provide equipment ground, internally mounted and labeled for copper and aluminum ground conductors.

E. Auxiliary Contact Kit: Provide 2 sets of auxiliary contacts arranged to open before switch blades open. Auxiliary contacts shall open before the main switch blades open.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Provide overload relay in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

B. Where fuse ampere trip ratings are not indicated in the drawings, select the trip rating in accordance with the manufacturer's recommendations and NEC requirements.

C. All controllers shall be padlockable in the ON or OFF positions. Provide one padlock and 3 keys for each controller.

D. All combination starters shall have the following items:
1. Hand-Off-Automatic Selector Switch
2. RED push-to-test LED light to indicate motor running
3. GREEN push-to-test LED light to indicate motor stopped
4. Momentary contact push button for manual motor start
5. Momentary contact push button for manual motor stop
6. Solid state overload relay
7. Auxiliary contacts

3.3 INSTALLATION

A. Enclosed Controller Fuses: Install fuses in each fusible switch.

3.4 IDENTIFICATION

A. Identify enclosed controller, components, and control wiring.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers.

B. Bundle, train, and support wiring in enclosures.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Engage a qualified testing agency and perform the following tests and inspections, and prepare test reports:

    a. Perform each visual and mechanical inspection and electrical test stated in the NETA Acceptance Testing Specification. Certify compliance with test parameters.

        1) Electrical tests are required for combination starters. Visual and mechanical inspections are required on all starters (including, but not limited to, manual starters and combination starters).

2. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.

3. Remove and replace items which do not pass the tests. Test the replacement items.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers. Provide a minimum of 4 hours of training unless otherwise noted.

END OF SECTION

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Touch up paint
6. Common electrical installation requirements.
7. Wire guards.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

C. NECA: National Electrical Contractors Association

1.4 SUBMITTALS

A. Product Data: Provide product data for all items indicated in this specification section.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. Connecting raceways, cables, wireways, cable trays, and busways shall be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

D. Coordinate sleeve selection and application with selection and application of firestopping.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 ACCESS DOORS

A. Door and frame shall be constructed of steel, 16 gauge minimum. Access door shall have a continuous piano hinge. Door shall have a flush mounted lock. Finish shall be prime coat of rust inhibitive electrostatic powder, baked enamel. Access door shall be field painted to match the surrounding wall or ceiling.

B. Provide fire rated access doors to maintain the fire rating of wall and ceiling assemblies, to restore original fire-resistance rating of assembly.

2.5 DUCT-SEALING COMPOUND

A. Duct-sealing compound shall be Polywater FST Foam Sealant or approved equal. Duct-sealing compound shall be a 2-part, 98% closed-cell urethane foam. It shall react and set in 5-10 minutes at 70 degrees F. It shall be capable of sealing 3/4" to 10" conduits with multiple cable configurations. Duct-sealing compound shall be re-enterable. It shall be capable of withstanding temperatures from -20 degrees F to 200 degrees F continuous, and be chemically resistant to gasoline, oils, dilute acids, and bases. Duct-sealing compound shall not affect the physical or electrical properties of wires and cables.

B. Duct-sealing compound shall have good adhesion to duct and cable jacket surfaces with good structural strength. It shall have 120 lb compressive strength (ASTM D1621). Duct-sealing compound shall be capable of holding 22 feet water head pressure continuous, or 90 feet water head pressure short-term. It shall block up to 5 psi gas or vapor continuous. It shall meet NEC codes for Raceway Seals, meet UL 94 fire rating HBF, and be UL recognized.

C. Duct-sealing compound shall be compatible with the wires/cables used in the project. The cured foam is an inert solid that does not affect wire/cable components. It does not change the physical or electrical properties of wires/cables, based on tensile – elongation and volume resistivity testing.

D. Duct-sealing compound shall have excellent adhesion to PVC, rigid steel, EMT, IMC, fiberglass, and polyethylene conduits.

2.6 TOUCH UP PAINT

A. Provide touch up paint from the manufacturer of the electrical equipment. Paint shall match the finish of the equipment. At a minimum, provide touch up paint for all power distribution equipment.

2.7 WIRE GUARDS

A. Where wire guards are required by the contract documents, provide wire guards from the same manufacturer as the equipment being protected, unless otherwise noted and except as follows:
   1. Where the manufacturer of the equipment does not provide a wire guard, provide a wire guard from another manufacturer that manufacturers wire guards, such as wire/protective guards/cages from Safety Technology International . Where a standard wire guard is not suitable for the application or is not compatible with the equipment, provide a custom wire guard. Coordinate with the wire guard manufacturer as required.
   2. For electrical power and data outlets, cast aluminum weatherproof covers (lift to open) shall be used in lieu of wire guards. Where these types of covers are not available for the

type/size of outlet, provide a clear polycarbonate cover (lift to open) from Safety Technology International or approved equal.

3. For pushbuttons, fire alarm manual pull stations, and other devices that require access by hand to operate, provide a clear polycarbonate cover (lift to open) from Safety Technology International or approved equal. The covers shall have an appropriate label describing the equipment being protected.

B. Wire/protective guards/cages and other covers shall have sufficient size to enclose/protect the associated equipment, and shall not impede, obstruct, or prevent the equipment being protected from operating to its fullest extent. The equipment manufacturer's installation requirements (including, but not limited to, equipment clearances) shall be followed at all times. All work shall comply with the manufacturer's recommendations and the contract documents.

C. Where Wire/Protective Guards/Cages and other covers are located less than 7' above finished floor, it shall extend not more than 4" from the wall.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Comply with NFPA 70, National Electrical Code.

C. Mounting heights indicated in the contract documents are measured from the finished floor or finished grade to the bottom of the equipment, unless otherwise noted.

D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

F. Right of Way: Give to piping systems installed at a required slope.

G. Where underground ducts or conduit enter the building, the inside of the ducts or conduit shall be sealed with Duct-Sealing Compound.

H. Provide touch up paint as required on equipment finishes that have been scratched, and provide touch up paint as directed by the engineer. Touch up paint shall be provided in accordance with the manufacturer's recommendations. Do not allow paint to come in contact with conductors, insulation or any live parts. All nameplates and labels shall remain visible and legible.

I. Overcurrent devices shall be readily accessible and shall be installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 6 feet 7 inches above the floor or working platform.

J. All exterior wall penetrations shall be made watertight. Seal inside and around conduit as required. The inside of the conduit shall be sealed with Duct-Sealing Compound.

K. Provide access doors where required to keep concealed electrical devices and equipment accessible in accordance with the National Electrical Code.

L. Unless otherwise noted, access doors shall be painted to match surrounding wall or ceiling.

M. Enclosures, troughs, wireways, boxes and raceways which contain unmetered wiring, shall be provided with a suitable means to accommodate the seals of the electric utility. Coordinate with electric utility and comply with their requirements.

N. Provide boards, channels, blocking, wall anchors, screws, hardware, and other supports for mounting electrical equipment on walls. Where the electrical equipment are mounted in finished spaces (including, but not limited to, offices, etc.), the supports shall be concealed. Where the electrical equipment are mounted in wet locations, the supports shall be suitable for wet locations.

O. Where electrical equipment are mounted above suspended ceilings, provide coordinate exact location of the equipment such that it does not block or prevent the removal/operation of ceiling tiles and access doors.

P. Where underground conduit enter buildings, and terminate at electrical equipment (including, but not limited to, panelboards, enclosed circuit breakers, lighting relay panels, etc.), the conduit shall terminate at the bottom of the electrical equipment, unless otherwise noted.

Q. The top of control panels shall not be higher than 6'above the finished floor, and the bottom of control panels shall not be lower than 15" above the finished floor (exact mounting height shall be coordinated in the field), unless otherwise noted and except as follows:
   1. Where control panels cannot fit on the wall, due to size/quantity of all equipment mounted on the wall, the top of the control panels can be increased or the bottom of the control panels can be decreased, as long as all of the following conditions are met:
      a. Where the control panels have displays (LCD, etc.), visible indicators (LED lights, etc.), or manual operators (switches, buttons, keypads, etc.), the top part of the highest display, visible indicator, or manual operator is less than 6' above the finished floor; and, the bottom part of the lowest display, visible indicator or manual operator is not lower than 15" above the finished floor.
      b. The bottom of the control panel is not less than 12" above the finished floor.
      c. Where ventilation clearances are required, there is proper ventilation around the control panel, in accordance with the manufacturer's recommendations.
      d. The mounting heights are coordinated with all other equipment on the wall.
      e. All work complies with the NEC, the manufacturer's recommendations, and the contract documents.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

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

B. Install UL Listed Firestopping Material in accordance with the manufacturer's recommendations, and UL's requirements.

END OF SECTION

SECTION 26 05 19 - CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

A. AWG: American Wire Gauge

B. KCMIL: Thousand Circular Mil

1.4 SUBMITTALS

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

B. Field Quality Control Test Reports

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. General Cable Corporation.
   2. Southwire Company.
   3. Encore Wire.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation:

   1. THHN/THWN-2 Wire:
      a. Complies with NEMA WC 70
      b. Listed to UL 83
      c. Suitable for operation at 600 volts or less in wet or dry locations.
      d. 90 degree C rated in wet or dry locations.
   2. XHHW-2 Wire:
      a. Complies with NEMA WC 70
      b. Listed to UL 44
      c. Suitable for operation at 600 volts or less in wet or dry locations
      d. 90 degree C rated in wet or dry locations.
      e. Insulation is an abrasion, moisture, and heat resistant cross-linked polyethylene (XLP)

D. Branch Circuit Type Metal Clad Cable:

   1. Conductor Insulation: THHN 90 degree C
   2. Copper conductor.
   3. Neutral wire shall be insulated and shall be the same size as the phase conductors.
   4. Voltage Rating: 600V
   5. Conductor covering: Polypropylene assembly tape overall
   6. Armor: Interlocked galvanized steel
   7. Fire Wall Rated for 1, 2 and 3 hour rated penetrations
   8. Grounding Means: One insulated copper grounding conductor, unless otherwise noted.
   9. Suitable for use in environmental air handling spaces
   10. UL 1569 Listed

E. TC-ER-JP Multiconductor Cable
   1. Conductors: Stranded, copper conductors
   2. Insulation: High dielectric strength, heat and moisture-resistant, colored PVC rated for 90 degree C dry or wet to meet UL-83 requirements for type THHN or THWN-2 wire
   3. Assembly: The insulated conductors are cabled together. Nylon rip-cord is supplied for easy stripping.
   4. Color Coding: Per ICEA Method 1
   5. Overall Jacket: Flame retardant, sunlight-resistant, black PVC jacket.
   6. Applications: Suitable for installation in channels, ducts, wireways, cable trays, and raceways. Approved for direct burial in wet or dry locations and outdoors in cable trays.
   7. UL 83, UL 1277, UL 1581, and UL 2556 Listed
   8. ASTM Stranding Class B3, B8, B787
   9. Complies with NEC Article 336

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. 600V Vinyl Insulating Tape: The tape is based on polyvinyl chloride (PVC) and/or its copolymers and has a rubber based, pressure-sensitive adhesive. The tape shall be 7 mils thick, and UL Listed and marked per UL Standard 510 as "Flame Retardant, Cold and Weather Resistant."

D. Screw-on Pressure Cable Connector: Connector shall be UL Listed. Voltage rating shall be 600 volts for building wire and 1000 volts for signs and fixtures.

E. Mechanical Connector: Connector shall be UL Listed. Connector shall be wrapped with electrical insulating tape in accordance with the NEC and the manufacturer's requirements. Connectors shall be dual rated (suitable for use with copper or aluminum conductors), unless other wise noted.

F. Compression Connector: Connector shall be UL Listed. Connector shall be wrapped with electrical insulating tape in accordance with the NEC and the manufacturer's requirements. Use compression tool recommended by manufacturer. Connectors shall be dual rated (suitable for use with copper or aluminum conductors), unless other wise noted.

G. Submersible Connectors and Splices: Submersible connectors and splices shall have all of the following features:
1. UL listed as a sealed wire-connector system
2. UL 486D Listed for direct burial and submersible applications

PART 3 - EXECUTION

3.1 CONDUCTOR/WIRE SIZES

A. Conductor/wire sizes are indicated in the drawings. Where conductor/wire sizes are indicated in both the power one-line/riser diagrams, and the panel/panelboard/switchboard schedules, the conductor/wires sizes indicated in the power one-line/riser diagrams shall take precedence.

3.2 CONDUCTOR MATERIAL APPLICATIONS

A. Service: Copper. Stranded.

B. Feeders: Copper. Stranded.

C. Branch Circuits: Copper.

1. Solid for No. 10 AWG and smaller, unless otherwise noted and except as follows:

   a. Where the conductors connect to vibrating equipment (including, but not limited to, transformers, motors, and generators), the conductors shall be stranded.

   b. Where the equipment manufacturer recommends stranded conductors, the associated conductors shall be stranded.

2. Stranded for No. 8 AWG and larger.

D. Class 1 and Class 2 Control Wiring: Copper. Stranded.

3.3 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Aboveground Service Entrance: Type THHN/THWN-2, single conductors in raceway, unless otherwise noted.

B. Aboveground Exposed Feeders: Type THHN/THWN-2, single conductors in raceway, unless otherwise noted.

C. Aboveground Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway, unless otherwise noted.

D. Aboveground Exposed Branch Circuits: Type THHN/THWN-2, single conductors in raceway, unless otherwise noted and except as follows:

1. Wiring on the load side of Variable Frequency Drives: Type XHHW-2 single conductors in raceway, unless otherwise noted.

E. Aboveground Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway, unless otherwise noted and except as follows:

1. Branch Circuit Type Metal Clad Cable may be used in lieu of THHN/THWN-2, single conductors in raceway where ALL of the following conditions are met:
   a. Metal Clad Cable is fed from circuit breakers or fuses rated at 20 amperes or less.
   b. Metal Clad Cable is only used for branch circuit conductors.
   c. Metal Clad Cable is used only in dry locations.
   d. Metal Clad Cable is used only in aboveground applications.
   e. Metal Clad Cable is not subject to physical damage.
   f. Metal Clad Cable is used only in concealed ceilings, walls, and partitions.
   g. Metal Clad Cable is installed only where allowed by the National Electrical Code, NFPA Codes, and Federal/State/Local Codes.

2. Wiring on the load side of Variable Frequency Drives: Type XHHW-2 single conductors in raceway, unless otherwise noted.

3. Wiring inside light poles, where all branch circuits within the light pole are fed from circuit breakers or fuses rated at 20 amperes or less; and, where data/communications wiring are run within the same light pole for cameras or other equipment:

   a. Use TC-ER-JP Multiconductor Cable. The wires which are used as equipment grounding conductors shall be marked green, using 600V rated, UL listed, green

electrical tape at each end, and at every point the wires are accessible (including, but not limited to, wires which are accessible through the handhole of the light pole). Splice the multiconductor cable to the rest of the branch circuit wiring near the bottom of the light pole, where the splices are accessible through the handhole of the pole.

F. Aboveground Class 1 and Class 2 Control Wiring: Type THHN/THWN-2, single conductors in raceway unless otherwise noted.

G. Underground Service, Feeders and Branch Circuits: XHHW-2 single conductors in raceway, unless otherwise noted. The wiring shall be type XHHW-2 from end-to-end, regardless of whether or not the wiring starts or ends aboveground or underground. For example, a branch circuit for an underground lighting circuit shall be XHHW-2 from where the branch circuit starts (at the aboveground panelboard), up to where it ends (at the aboveground light pole).

H. Underground Class 1 and Class 2 Control Wiring: XHHW-2 single conductors in raceway, unless otherwise noted. The wiring shall be type XHHW-2 from end-to-end, regardless of whether or not the wiring starts or ends aboveground or underground. For example, a branch circuit for an underground lighting circuit shall be XHHW-2 from where the branch circuit starts (at the aboveground panelboard), up to where it ends (at the aboveground light pole).

3.4 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with the NEC.

B. Comply with the manufacturer's recommendations and requirements.

C. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

G. Identify and color-code conductors and cables according to Specification Section "Electrical Identification."

H. Do not splice feeders and underground branch circuits unless specifically indicated in the drawings. Wires shall be unspliced between termination points.

I. Provide insulated bushings at the end of each Metal Clad Cable.

J. Use insulating bushings to protect ALL conductors, including conductors smaller than No. 4 AWG. Provide insulated grounding bushings where required by NFPA 70 or the Contract Documents.

K. Cables associated with roof mounted equipment or outdoor wall mounted equipment shall run concealed inside the building.

L. Spare wires shall be disconnected at both ends and shall be insulated at both ends with wire nuts held in place by electrical insulating tape. For large wire sizes, the spare wires shall be disconnected at both ends and shall be insulated at both ends with double wrapped electrical insulating tape.

M. Provide dedicated neutral wires for all branch circuits.

N. Do not combine separate feeder circuits in the same raceway, unless otherwise noted.

O. Do not combine separate branch circuits in the same raceway, unless otherwise noted and except as follows:
   1. Branch circuits may be combined in the same raceway where ALL of the following conditions are met:
      a. The branch circuits being combined in the same raceway serve the same area or adjacent areas.
      b. The branch circuits being combined in the same raceway homerun to the same panelboard.
      c. The number of branch circuits being combined in the same raceway does not exceed 3.
      d. The number of current carrying conductors installed in the same raceway does not exceed 6.
      e. The branch circuits are installed in a manner that does not subject them to any ampacity derating, except for the ampacity derating caused by having 4 to 6 current carrying conductors in the same raceway.
      f. The branch circuits that are being combined in the same raceway are all fed from 1-pole circuit breakers that have a trip rating of either 15 amperes or 20 amperes.
      g. The branch circuits that are being combined in the same raceway are not fed from circuit breakers that have a trip rating greater than 20 amperes.
      h. The branch circuits that are being combined in the same raceway are limited to 1-phase circuits that have a voltage of either 120V or 277V.
      i. The smallest wire size, in the branch circuits which are being combined in the same raceway, is not smaller than #12 AWG.
      j. The wires that are combined in the same raceway do not exceed the NEC wire fill capacity of the raceway. The raceway size is increased as required to comply with NEC requirements.
      k. The branch circuits which are being combined in the same raceway are limited to lighting and receptacle branch circuits.
      l. Dedicated neutral wires are provided for all branch circuits.
      m. Ground wires are provided in accordance with NEC requirements. Grounding and bonding are provided in accordance with NEC requirements.
      n. Where the NEC does not allow branch circuits to be combined in the same raceway, the branch circuits are not combined in the same raceway.
      o. All work complies with the NEC, the manufacturer's recommendations, and the contract documents.

P. All metal clad cable shall be concealed, unless otherwise noted.

Q. Underground splices of service, feeder, and branch circuits shall not be permitted, unless otherwise noted.

   1. Where the drawings specifically indicate that underground wires shall be spliced, submersible splices and connectors shall be used. The contractor shall mark the locations of the underground splices on the as-built drawings.

R. Where wires larger than #10 AWG are installed on 15A or 20A branch circuits, splice #10AWG "pigtails" for connections to circuit breakers, devices and equipment. "Pigtails" in this paragraph

shall mean short leads used to connect a circuit breaker, device or equipment to branch circuit wires. Comply with all of the following:

1. Length of the wires of the "pigtails" shall be less than 48", unless otherwise noted and except as follows:
   a. At light poles, the length of the "pigtails" shall be increased to match the height of the light pole such that the "pigtail" splice is located in the handhole at the base of the pole. The length of the "pigtail" shall not exceed 125% of the overall height of the light pole.
2. Where the "pigtails" are run inside raceways, the length of the raceways shall be less than 23", and the raceways shall be sized per NEC requirements.
3. Provide junction boxes as required for splicing wires.
4. The wire size of the phase, neutral, and ground wires of the "pigtails" shall not be less than #10AWG, except as follows:
   a. The wire size of the phase, neutral and ground wires of the "pigtails" shall be #12AWG where the wire terminals at the circuit breaker, device, or equipment are not suitable for wires larger than #12AWG.
   b. The wire size of the phase, neutral and ground wires of the "pigtails" shall be #12AWG for the aboveground wiring at light poles.
5. All work shall comply with NEC, the manufacturer's recommendations, and the contract documents.

S. Splicing wires in handholes, manholes, and other underground structures shall not be allowed, unless otherwise noted. Provide wire reels with wires that are coordinated with the overall length of the associated electrical circuit. The wires on the wire reels shall have a continuous length that is not less than the distance between splice points on the associated electrical circuit. For example, where wires are run through 2000 feet of underground ductbanks and manholes, the continuous length of the wires on the wire reels shall not be less than 2000', so that the wires do not need to be spliced inside the manholes.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Engage a qualified testing agency and perform the following tests and inspections, and prepare test reports:
   a. Perform each visual and mechanical inspection and electrical test stated in the NETA Acceptance Testing Specification. Certify compliance with test parameters.
      1) Electrical tests (this includes, but is not limited to: insulation resistance testing) are required on all wiring that is #2 AWG and larger, and all sizes of underground wiring. Visual and mechanical inspections are required on all wiring.

2. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.
3. Remove and replace items which do not pass the tests. Test the replacement items.

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise noted.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

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

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller (exception: conductors for vibrating equipment, such as transformers, motors and generators, shall use stranded conductors; or, where stranded conductors are recommended by the manufacturer of the equipment, use stranded conductors), and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors.
3. Connections to Structural Steel: Welded connectors.

C. Where ground wires are installed in the same raceway, box, or enclosure as medium voltage cables, the ground wires shall have 600V insulation, unless otherwise noted. The ground wiring shall be type XHHW-2 from end-to-end, regardless of whether or not the wiring starts or ends aboveground or underground, unless otherwise noted.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. This includes, but is not limited to, low and medium voltage feeders and branch circuits.

B. Unless otherwise noted, all equipment grounding conductors shall be insulated.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 70, NFPA 780 and UL 96 when interconnecting with lightning protection system.

C. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

D. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts.

E. Ground cable shielding, metallic conduits, wireways, cable boxes, luminaires, light poles, electrical equipment housings, and all noncurrent carrying metallic parts.

F. All metal conduit stub-ups shall be grounded, and where multiple stub-ups are made within an equipment enclosure, they shall be equipped with grounding bushings, bonded together, bonded to the enclosure, and bonded to the enclosure ground bus/terminal.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Engage a qualified testing agency and perform the following tests and inspections, and prepare test reports:
   a. Perform each visual and mechanical inspection and electrical test stated in the NETA Acceptance Testing Specification. Certify compliance with test parameters.
      1) Measure/record the resistance-to-ground, and verify that grounding has been installed in accordance with NEC requirements, for the following equipment (where the equipment are being furnished and installed as part of the project):
         a) Separately derived systems (including, but not limited to, step-down/up transformers)
         b) Generators
         c) Service Equipment
         d) Electrical and Telecommunications Ground Bars
2. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.
3. Remove and replace items which do not pass the tests. Test the replacement items.

END OF SECTION

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. RMC: Rigid metal conduit.

B. MFMA: Metal Framing Manufacturer's Association

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

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. Thomas & Betts Corporation.
e. Unistrut; Tyco International, Ltd.
f. Hilti

2. Comply with the following for Outdoor Locations, unless otherwise noted:
   a. Steel Channel Metallic Coatings: Hot-dip galvanized after fabrication in accordance with ASTM A123 and applied according to MFMA-4.
   b. Fittings and Accessories:
      1) Conduit hangers, conduit clamps, beam clamps, and wall brackets shall be steel, hot-dip galvanized after fabrication in accordance with ASTM A123.
      2) Threaded hardware such as mechanical expansion anchors, nuts, bolts, and threaded rods shall be steel, hot-dip galvanized after fabrication in accordance with ASTM A123. Threaded hardware not available as hot-dip galvanized after fabrication shall be stainless steel type 304.
3. Comply with the following for Indoor Locations, unless otherwise noted:
   a. Steel Channel metallic Coatings: Pre-Galvanized Steel with mill galvanized coating designation G90.
   b. Fittings and Accessories:
      1) Conduit hangers, conduit clamps, beam clamps, and wall brackets shall be pre-galvanized (designation G90) or electroplated zinc (ASTM B633).
      2) Threaded hardware shall be electroplated zinc (ASTM B633).

4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

2. Concrete Inserts: Steel slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.
7. Fire retardant plywood board:
   a. Provide Hoover Treated Wood Products Inc, Pyro-Guard Interior Fire-Retardant-Treated Wood or approved equal, except where the architectural/structural drawings/specifications indicate that a different product be used, in which case the architectural/structural drawings/specifications shall take precedence. The plywood board shall have the following features:
      1) Plywood board shall have a flame spread rating of 25 or less (Class A) when tested in accordance with ASTM E84, "Standard Test Method for Surface Burning Characteristics of Building Materials". Plywood board shows no evidence of significant progressive combustion when the test is extended for an additional 20-mionute period. In addition, the flame front does not progress more than 10 ½ feet beyond the centerline of the burners at any time during the test. The flame spread and smoke developed index for each species and product are classified by Underwriters Laboratories Inc (UL).
      2) Plywood board is manufactured under the independent third-party inspection of UL Follow-Up Service and each piece shall bear the UL classified mark indicating the extended 30 minute ASTM E84 test.

F. Steel Reinforcement
1. General: Reinforcement bars shall be Epoxy-Coated
2. Epoxy-Coated Reinforcement Bars shall comply with the following:
   a. Epoxy Coating: ASTM A775
   b. Steel Reinforcement Bars: ASTM A615, Grade 60, deformed bars.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Provide fire retardant plywood board as required for mounting equipment on the walls. Coordinate width and height of board with the quantity/sizes of equipment being mounted to it.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

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

E. The use of powder-actuated tools is not allowed.

F. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.

G. Do not use spring steel clips and clamps.

H. In wet or damp locations, use steel channel supports to standoff non-recessed, wall mounted cabinets and panelboards, at least one inch from the mounting surface.

I. Provide all necessary blocking, channels and other hardware for securing electrical equipment (including, but not limited to, panelboards) to the wall, column, or other parts of the building structure. The blocking/channels shall be concealed inside the hollow spaces of the wall where all of the following conditions are met:
   1. The equipment is located inside a dry indoor location.
   2. The equipment is located outside electrical/mechanical rooms.
   3. The equipment is mounted on a drywall or a similar wall with a hollow space inside the surface of the wall.

J. Where electrical equipment (including, but not limited to, lighting fixtures, wiring, conduit, etc.), or the items to which the electrical equipment are attached to or supported from (including, but not limited to, metal channels, junction boxes, etc), are suspended, and the vertical length of the supports (including, but not limited to, threaded rods) for these equipment/items are longer than 48 inches, provide bracing supports to prevent swinging of the equipment/items.

K. Suspended electrical equipment (including, but not limited to, lighting fixtures, wiring, conduit, etc.) shall be supported from the building structure. Where suspended electrical equipment are not located directly under roof trusses, roof supports, or other structural elements, or where other equipment (mechanical, plumbing, etc) are located above the electrical equipment, provide metal channels and other supports to span, or attach to, the roof trusses, roof supports, or other structural elements. The electrical equipment shall be installed at the locations indicated in the Contract Documents, and metal channels and other supports shall be provided as required in order to support the electrical equipment.

L. Provide supports for conductors in vertical conduit in accordance with the manufacturer's recommendations and NEC requirements.

M. Where racks or cabinets are wall mounted, provide metal channels or fire retardant plywood boards that are capable of supporting the equipment mounted on it, to span and attach to the wall studs, wall columns, or other wall elements. Where the wall elements cannot support the racks or cabinets, provide independent freestanding supports for the racks or cabinets. The metal channels, boards, and supports shall be painted to match adjacent wall surfaces where installed in finished spaces (including, but not limited to, offices, conference rooms, etc.)

N. Fire retardant plywood boards shall be furnished and installed in accordance with all of the following:
   1. The plywood boards shall be furnished and installed in accordance with the manufacturer's recommendations, UL's requirements, and the applicable codes.
   2. The plywood boards shall only be installed in dry indoor locations.
   3. The plywood boards shall only be used as a mounting surface for electrical equipment.
   4. Do not exceed the load rating/capacity of the plywood boards.
   5. Where the drawings do not indicate the dimensions of the plywood board, the length and width of the plywood board shall not be less than what is required to support the associated equipment; and, the thickness of the plywood board shall not be less than what is required to support the associated equipment, or ¾" thick, whichever is thicker.

O. Where equipment are ceiling mounted, and the equipment are intended to be accessible or visible from below the ceiling (including, but not limited to, ceiling mounted receptacles and data outlets associated with ceiling mounted projectors, wireless access points, and audio/visual devices/converters; or, ceiling mounted fire alarm devices, occupancy/daylight sensors, speakers, or cameras), comply with the following:
   1. The equipment shall be mounted on the bottom surface of the suspended ceiling. Where the equipment is available with a recessed enclosure/box, the enclosure/box shall be

recessed into the ceiling, and the bottom of the equipment shall be flush with the ceiling. Where the equipment is not available with a recessed enclosure/box, it shall be surface mounted to the bottom of the ceiling.

2. Rigid supports, such as threaded rods, shall attach the equipment to the building structure. Provide mounting plates/channels and other hardware accessories as required. Operating the equipment (including, but not limited to, inserting plugs and jacks into outlets) shall not cause the equipment to move.
3. Equipment shall be accessible/operable from below the suspended ceiling.
4. Where there is no suspended ceiling, the equipment shall be suspended, and the mounting height of the equipment shall be coordinated in the field.

P. Steel Reinforcement
1. Apply epoxy repair coating to uncoated or damaged surfaces of epoxy-coated reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement.

Q. Provide independent freestanding supports for equipment as required.

3.3 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3500-psi, 28-day compressive-strength concrete, unless otherwise indicated.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

D. Concrete Pad Protection and Curing:
1. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
2. Cure concrete for at least 28 days

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 DEFINITIONS

A. FMC: Flexible metal conduit.

B. LFMC: Liquidtight flexible metal conduit.

C. RNC: Rigid nonmetallic conduit.

D. EMT: Electrical metallic tubing.

E. Where RGS (Rigid Galvanized Steel) Conduit, GRS (Galvanized Rigid Steel) Conduit, or RMC (Rigid Metal Conduit) are indicated in the contract documents, this shall mean Rigid Steel Conduit.

F. Conduit shall mean raceway of circular cross section, and shall include, but not be limited to, FMC, LFMC, RNC, EMT, and RGS conduit.

1.3 SUBMITTALS

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

B. Source quality-control test reports.

C. Provide coordination drawings where conduit or floorboxes are embedded in the concrete floor slab, for review/approval by the structural engineer.

1.4 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Anamet Electrical, Inc.; Anaconda Metal Hose.
4. O-Z Gedney; a unit of General Signal.
5. Wheatland Tube Company.
6. Robroy Industries Electrical Products Division

B. Rigid Steel Conduit:
1. Manufactured in accordance with ANSI C80.1.
2. UL 6 Listed

C. FMC:
1. UL 1 Listed. UL Type RW (Reduced Wall)
2. Zinc-coated steel construction

D. EMT:
1. Manufactured in accordance with ANSI C80.3
2. UL 797 listed
3. Fittings: Set-screw or Compression type.

E. LFMC:
1. UL 360 Listed
2. Flexible steel conduit with PVC jacket.
3. PVC jacket shall be moisture, oil and sunlight resistant.

F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), and Cable: NEMA FB 1; UL listed for type and size raceway with which used, and for application and environment in which installed.
1. Insulating Bushings: Plastic, 105 degree C minimum temperature rating.
2. Insulated Grounding Bushings: Malleable Iron with plastic liner, 105 degree C minimum temperature rating.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. CANTEX Inc.
4. Condux International, Inc.
5. Electri-Flex Co.
6. Lamson & Sessions; Carlon Electrical Products.
7. RACO; a Hubbell Company.
8. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC (PVC Schedule 40) and Type EPC-80-PVC (PVC Schedule 80), UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B. RNC shall be sunlight resistant and rated for use with 90 degree C conductors.

2.3 METAL TROUGHS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Covers: Screw-cover type, unless otherwise noted

D. Finish: ANSI 61 gray polyester powder paint finish inside and out over phosphatized surfaces.

2.4 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type, unless otherwise noted

E. Finish: ANSI 61 gray polyester powder paint finish inside and out over phosphatized surfaces.

2.5 ROOFTOP SUPPORTS FOR CONDUIT

A. Where conduit is mounted on top of flat rooftops, provide B-LINE DURA-BLOK rooftop supports to support the conduit. The rooftop supports shall have the following features:
1. Overall height of the support shall not be less than 5".
   a. The clearance from the bottom of the conduit to the top of the roof shall not be less than 5".
2. Built-in metal channel
3. Load capacity shall be selected to provide a minimum of 5 times safety factor
4. Made from 100% recycled rubber
5. Reflective strip on both sides allow for easy product visibility

6. Channel is through bolted on all sides for added strength
7. Product composition is not sharp or abrasive
8. UV resistant
9. Suitable for any type of roofing material or other flat surface.

2.6 FLOOR BOXES

A. Three-Compartment Floor Box shall include, but not be limited to the following components indicated below (provide additional hardware, accessories, and devices for a complete and fully operational floor box system):
   1. Cast-iron Floor Box: Provide Wiremold 880CM3-1 three-gang shallow cast iron floor box, fully adjustable, or approved equal with the following features:
      a. A divider shall be provided to separate the three compartments.
      b. Dimension 5 3/16" x 12 ½" x 2 7/16".
      c. Conduit Openings: (8) 1"
   2. Cover Plate Flange: Provide Wiremold 837B three-gang, brass combination carpet and tile flange or approved equal with the following features:
      a. Suitable for receptacle and telephone/data outlets
      b. Suitable for carpet, tile or concrete floor applications
   3. The floor box shall have the following features:
      a. Floor box shall have TopGuard protection (an integral design which keeps out water, dirt, and debris from the power and communication compartments).
      b. Fully adjustable box. Before and after concrete pour adjustability.
      c. Concrete tight cast-iron constructions. Meets requirements for on grade or below grade application.
      d. Suitable for use in carpets, tiles or concrete floors.
      e. Complies with UL Scrub Water Standards.
      f. Water shall not enter power outlets during routine wet mopping and carpet shampooing.
      g. Suitable for installation in concrete floors.
   4. Comply with the following for compartments with duplex receptacles:
      a. Coverplate shall be Wiremold 828R brass duplex cover plate or approved equal. Provide faceplate, modules, adapters, and other accessories as required for the installation of the receptacle.
   5. Comply with the following for compartments with telephone/data/audio visual outlets:
      a. Coverplate shall be Wiremold 828GFITC brass cover plate or approved equal. Provide faceplate, modules, adapters, inserts, and other accessories as required for installation of the telephone/data/coax/HDMI jacks.
   6. Provide all associated mounting hardware and accessories.

B. Two-Compartment Floor Box shall include, but not be limited to the following components indicated below (provide additional hardware, accessories, and devices for a complete and fully operational floor box system):
   1. Cast-iron Floor Box: Provide Wiremold 880CM2-1 two-gang shallow cast iron floor box, fully adjustable, or approved equal with the following features:
      a. A divider shall be provided to separate the two compartments.
      b. Dimension 5 3/16" x 8 ½" x 2 7/16".
      c. Conduit Openings: (6) 1"
   2. Cover Plate Flange: Provide Wiremold 827B two-gang, brass combination carpet and tile flange or approved equal with the following features:
      a. Suitable for receptacle and telephone/data outlets
      b. Suitable for carpet, tile or concrete floor applications
   3. The floor box shall have the following features:
      a. Floor box shall have TopGuard protection (an integral design which keeps out water, dirt, and debris from the power and communication compartments).

b. Fully adjustable box. Before and after concrete pour adjustability.
c. Concrete tight cast-iron constructions. Meets requirements for on grade or below grade application.
d. Suitable for use in carpets, tiles or concrete floors.
e. Complies with UL Scrub Water Standards.
f. Water shall not enter power outlets during routine wet mopping and carpet shampooing.
g. Suitable for installation in concrete floors.

4. Comply with the following for compartments with duplex receptacles:
   a. Coverplate shall be Wiremold 828R brass duplex cover plate or approved equal. Provide faceplate, modules, adapters, and other accessories as required for the installation of the receptacle.
5. Comply with the following for compartments with telephone/data/audio visual outlets:
   a. Coverplate shall be Wiremold 828GFITC brass cover plate or approved equal. Provide faceplate, modules, adapters, inserts, and other accessories as required for installation of the telephone/data/coax/HDMI jacks.
6. Provide all associated mounting hardware and accessories.

2.7 BOXES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Hoffman.
4. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
5. O-Z/Gedney; a unit of General Signal.
6. RACO; a Hubbell Company.
7. Robroy Industries, Inc.; Enclosure Division.
8. Spring City Electrical Manufacturing Company.
9. Thomas & Betts Corporation.
10. Walker Systems, Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

2.8 ENCLOSURES AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Hoffman.

B. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

C. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 RACEWAY AND BOXES APPLICATION

A. Indoor locations:
   1. Raceway shall be EMT, unless otherwise noted and except as follows:
      a. Where raceway is used for supporting lighting fixtures, lighting control devices, occupancy sensors, photo sensors, wiring devices, receptacles, and other electrical equipment, the raceway shall be Rigid Steel Conduit, unless otherwise noted.
      b. Use Rigid Steel Conduit in damp or wet locations, unless otherwise noted.
      c. Conduit Larger than 4-inch trade size shall be Rigid Steel Conduit.
      d. Where raceway is subject to physical damage, use Rigid Steel Conduit, unless otherwise noted.
      e. For raceway embedded within a concrete/masonry wall or floor slab, use Rigid Steel Conduit, unless otherwise noted.
      f. Use FMC for connection to vibrating equipment (including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment), and for connection to equipment where the manufacturer recommends a flexible raceway, unless otherwise noted and except as follows:
         1) Use LFMC for damp or wet locations.
         2) Use LFMC where LFMC is recommended by the manufacturer of the equipment.
   2. Boxes and enclosures shall be NEMA 1, galvanized steel, unless otherwise noted, and except as follows:
      a. Boxes and enclosures in damp or wet locations shall be NEMA 3R, die cast aluminum, gasketed covers, unless otherwise noted and except as follows:
         1) Boxes and enclosures in shower rooms shall be NEMA 4X stainless steel type 304, unless otherwise noted.

B. Outdoor locations: Apply raceway and boxes products as specified below, unless otherwise noted:
   1. Raceway shall be Rigid Steel Conduit, unless otherwise noted and except as follows:
      a. For underground raceway (including, but not limited to, raceway below the bottom of the lowest floor slab of the building/structure), use PVC Schedule 40 conduit, unless otherwise noted.
      b. Use LFMC for connection to vibrating equipment (including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment), and for connection to equipment where the manufacturer recommends a flexible raceway, unless otherwise noted.
   2. Boxes and enclosures shall be NEMA 3R, die cast aluminum, gasketed covers, unless otherwise noted.

C. Wireways and Troughs: All Wireways and Troughs shall be metal, with ANSI 61 gray polyester powder paint finish inside and out over phosphatized surfaces, unless otherwise noted.

D. Minimum Raceway Size: 3/4-inch trade size, unless otherwise noted.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.

   1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise noted.

F. Conduit sizes:

1. Conduit sizes are indicated in the drawings. Where the conduit sizes are indicated in both the power one-line/riser diagrams, and the panel/panelboard/switchboard/conduit size schedules/tables, the conduit sizes indicated in the power one-line/riser diagrams shall take precedence.

G. Where the drawings show a floorbox and the type of floorbox is not indicated, provide a Two-Compartment Floor Box, unless otherwise noted and except as follows:
1. Where the size/quantity of receptacles, telecommunications, or data outlets indicated in the drawings will not fit in a Two-Compartment Floor Box, provide a Three-Compartment Floor Box.

3.2 INSTALLATION

A. Transitions from PVC conduit that is located underground (including, but not limited to, conduit below the bottom of the lowest floor slab of the building/structure), to aboveground metal conduit:
1. Where the conduit is coming through the floor, an equipment pad, or finished grade, change from PVC conduit to Rigid Steel Conduit 12" below the top of the floor/pad/grade, and continue with Rigid Steel Conduit up to 24" above the finished floor or grade, or up to the equipment which the conduit connects to, whichever is lower, unless otherwise noted. Above 24" or above the equipment, use the raceway specified in the RACEWAY AND BOXES APPLICATION paragraph of this Specification Section, unless otherwise noted. Metal conduit shall be grounded and bonded in accordance with the NEC.
a. Exceptions:
1) Where the PVC conduit turns up under freestanding, floor or concrete pad mounted, electrical equipment that completely enclosed and conceal the conduit, such as pad mounted switchboards/switchgear, the conduit shall be PVC conduit from underground up to where the conduit stops aboveground.
2) The conduit shall be PVC conduit from below floor or grade up to where the conduit stops at the following locations:
a) Outdoors, where PVC conduit turns up at the utility transformer.
b) Outdoors, where PVC conduit turns up at the utility poles
c) Indoors, where PVC conduit from the utility poles or utility manholes, containing telephone, cable tv and fiber internet service cables, turns up at the telephone terminal board in the electrical/telecom room.

B. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

C. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

D. Complete raceway installation before starting conductor installation.

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Raceway Terminations: Use insulating bushings to protect ALL conductors, including conductors smaller than No. 4 AWG. Provide insulated grounding bushings where required by NFPA 70 or the Contract Documents.

G. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

H. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

I. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Comply with the following:

1. Use LFMC where required by the Contract Documents.

J. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

K. Raceway shall run parallel or perpendicular to wall and ceiling structures (columns, joists, support beams, etc.) for a neat appearance.

L. All metallic raceways, boxes and enclosures shall be grounded.

M. Provide watertight hubs for all junction boxes and enclosures installed outdoors or in wet locations. Hubs used with NEMA 3R junction boxes and enclosures shall be NEMA 3R or NEMA 4X rated. Hubs used with NEMA 4 or 4X junction boxes and enclosures shall be NEMA 4X rated.

N. Underground raceway shall be made watertight.

O. Provide reducers as required to match the conduit size with the hub or conduit entry on the junction box or equipment. Install reducers in accordance with the manufacturer's recommendations and NEC requirements.

1. Where there are no available reducers in the sizes required, provide an interposing junction box between the larger conduit and the smaller hub or conduit entry, then provide a smaller conduit from the junction box to the hub or conduit entry. The size of the smaller conduit shall be the largest that can fit at the hub or conduit entry. Length of smaller conduit shall be less than 24". Do not exceed the conduit fill requirements indicated in the NEC. All work shall comply with the manufacturer's recommendations and NEC requirements.

P. Bending radius of conduit shall be selected to minimize wire or cable pulling tensions. Do not exceed the maximum pulling tension of the wire or cable manufacturer. Coordinate with wire or cable manufacturer.

Q. Raceway associated with roof or canopy mounted equipment shall run concealed under the roof or canopy.

R. Raceway associated with indoor or outdoor wall mounted equipment shall be concealed.

S. Where raceway is installed above the roof, the distance from the roof to the bottom of the raceway shall not be less than 4 inches. Provide mounting and supporting devices as required.

T. Floor Box Installation

1. Furnish and install floor box in accordance with the manufacturer's recommendation and NEC requirements.
2. Provide accessories as required for a complete installation.
3. Close unused raceway openings using the manufacturer's recommended accessories.
4. Coordinate floor box installation with the construction of the floor. Coordinate exact location of floor box with the owner/architect/engineer prior to installation.

U. Where the voltage between adjacent switches, receptacles or similar devices, in the same junction box or enclosure is 300V or greater, provide an internal securely installed barrier between the adjacent switches. Comply with NEC requirements.

V. All raceway shall be concealed, unless otherwise noted and except as follows:
1. Raceway may be exposed in electrical and mechanical rooms.

W. For surface mounted panelboards which are not located within electrical and mechanical rooms, the raceway from the finished floor to the bottom of the panelboard, and from the top of the panelboard to the ceilings space, shall be enclosed in a 3-sided trough that is 12 gauge steel minimum, and is painted to match the adjacent wall. The width and depth of the trough shall match the dimensions of the panelboards. The trough shall not prevent access/removal of the panelboard covers/doors.

X. Raceways/boxes and associated electrical equipment shall not block or impede the movement/operation of equipment that move (including, but not limited to, overhead doors, sliding doors, etc.).

Y. Where conduit is embedded in the concrete floor slab, comply with the following, unless otherwise noted:
1. Conduit spacing (center-to-center) shall be a minimum of three diameters of the largest conduit.
2. Conduit shall be placed in the middle 1/3 of the slab depth.
3. Comply with the floor details/reinforcement specified elsewhere in the contract documents. Coordinate with the structural engineer and provide a coordination drawing for his review/approval, to ensure that all structural requirements are met.

Z. Paint exposed raceway and boxes to match the surrounding ceiling, wall, and floor.

3.3 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

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

END OF SECTION

SECTION 26 05 40 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

B. OSHA: Occupational Safety and Health Administration

C. Duct: Conduit that are suitable for use underground

D. Ductbank: One or more ducts

E. Direct buried duct: Duct that is buried in the ground, without any concrete encasement

F. Direct buried ductbank: Ductbank that is buried in the ground, without any concrete encasement

G. AASHTO: American Association of State Highway and Transportation Officials

1.4 SUBMITTALS

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

B. Shop Drawings for Precast Concrete Manholes and Handholes, or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.

2. Reinforcement details.

3. Frame and cover design and manhole and handhole frame support rings.

4. Ladder details.

5. Grounding details.

6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.

7. Joint details.

8. Structural Calculations

9. Shop drawings, manhole/handhole drawings, and structural calculations shall be signed and sealed by a Professional Engineer licensed in the State of Maryland.

C. Duct-Bank Coordination Drawings: Show duct plans, duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

2. Show exact location/routing of all ductbanks and all outdoor equipment (including, but not limited to, manholes and handholes), as coordinated with all other site utilities and structures (including, but not limited to, wetlands, storm water ponds, drains, water/sanitary piping, hydrants, etc.), on a plan drawing at 1" = 20' scale. Indicate depth of ductbanks where they cross with other underground utilities and structures.

D. Field quality-control test reports.

E. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

F. Where manholes/handholes contain wiring furnished/installed by utility companies (including, but not limited to, wiring furnished/installed by electric, telecom, and tv utility companies, such as BGE, VERIZON, and COMCAST), these manholes/handholes shall be submitted to the associated utility company for their review and approval. Duct-bank coordination drawings shall also be submitted to the associated utility company for their review and approval.

G. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete (including, but not limited to, Polymer Concrete Handholes): Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.

2. Cover design.

H. As-built drawings shall be provided showing the quantities/routing/sizes/locations of underground ducts and utility structures. The as-built drawings shall indicate a section of all ductbank segments, indicating which wiring/circuits are run in each duct, and which ducts are spare.

1.5 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.7 COORDINATION

A. Coordinate elevation, layout and installation of ducts with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by the Owner and/or the Engineer.

C. Coordinate all work with the electric and telecom utilities (for example: BGE, VERIZON, COMCAST, etc.).

PART 2 - PRODUCTS

2.1 CONDUIT

A. RNC: NEMA TC 2, Type EPC-40-PVC (PVC Schedule 40) and Type EPC-80-PVC (PVC Schedule 80), UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B. RNC shall be sunlight resistant and rated for use with 90 degree C conductors.

2.2 DUCT ACCESSORIES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cantex, Inc.
2. Condux International, Inc.
3. Lamson & Sessions; Carlon Electrical Products.
4. Manhattan/CDT; a division of Cable Design Technologies.
5. Spiraduct/AFC Cable Systems, Inc.

B. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape

2.3 PRECAST CONCRETE MANHOLES AND HANDHOLES

A. Comply with ASTM C 858, and with interlocking mating sections, complete with accessories, hardware, and features.

1. Duct Entrances in Manhole and Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   a. Type and size shall match fittings to duct or conduit to be terminated.

   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes and handholes to facilitate racking of cable.

B. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

C. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

D. Precast Manholes and Handholes, when buried, shall be designed to support AASHTO HS20 loading.

E. Where manholes/handholes contain wiring furnished/installed by utility companies (including, but not limited to, wiring furnished/installed by electric, telecom, and tv utility companies, such as BGE, VERIZON, and COMAST), these manholes/handholes shall comply with the requirements of the associated utility company. The manholes/handholes (plus all associated utility structure accessories) shall be designed to support AASHTO HS20 loading, except where a greater load rating is required by the associated utility, in which case the greater load rating shall apply.

2.4 UTILITY STRUCTURE ACCESSORIES

A. Manhole and Handhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole and handhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 35B, with milled cover-to-frame bearing surfaces; 30" diameter clear opening, heavy duty.

   a. Cover Finish: Nonskid finish.

   b. Designed to support AASHTO HS20 loading.

2. Cover Legend: Cast in. Selected to suit system.

   a. Legend: As indicated on the drawings.

3. Manhole and Handhole Chimney Components: Precast concrete rings, AASHTO HS20 rated, with dimensions matched to those of roof opening.

   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.

B. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

C. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

D. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

E. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

F. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of 9 holes for arm attachment.

a. A minimum of 4 stanchions shall be located on each short wall of the manhole (2 in the upper half and 2 in the lower half of the manhole).

b. A minimum of 8 stanchions shall be located on each long wall of the manhole (4 in the upper half and 4 in the lower half of the manhole).

c. A minimum of 2 stanchions shall be located on each short wall of the handhole

d. A minimum of 2 stanchions shall be located on each long wall of the handhole

2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

a. Provide a minimum of two (2) 14" long arms per stanchion.

3. Hardware: Stainless Steel Type 316.

G. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

H. Warning Sign: Install "Confined Space Hazard" warning sign inside the manhole.

I. Where manholes/handholes contain wiring furnished/installed by utility companies (including, but not limited to, wiring furnished/installed by electric, telecom, and tv utility companies, such as BGE, VERIZON, and COMAST), these manholes/handholes shall comply with the requirements of the associated utility company. The manholes/handholes (plus all associated utility structure accessories) shall be designed to support AASHTO HS20 loading, except where a greater load rating is required by the associated utility, in which case the greater load rating shall apply.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Polymer Concrete Handhole:

1. Enclosures, boxes, and covers shall conform to all test provisions of the most current ANSI/SCTE 77 "Specification For Underground Enclosure Integrity" for Tier 22 applications. All covers are required to have the Tier level rating embossed on the surface. In no assembly can the cover design load exceed the design load of the box.

2. Handhole shall be tested by UL to meet the requirements of ANSI/SCTE 77. Handhole shall be UL Listed.

3. Handhole shall have an open bottom, unless otherwise noted.

4. Handhole design load (including box and cover) shall be 22,500 pounds.

5. Handhole cover shall be secured to the box with stainless steel bolts.

6. Handhole shall be manufactured by Quazite or approved equal. See drawings for dimensions of handhole.

2.6 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Polymer Concrete Handhole: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

PART 3 - EXECUTION

3.1 DUCT APPLICATION

A. Direct-buried ducts: Duct shall be NEMA TC 2, Type EPC-40-PVC (PVC Schedule 40), unless otherwise noted on the drawings.

B. Concrete encased ducts: Duct shall be NEMA TC 2, Type EPC-40-PVC (PVC Schedule 40), unless otherwise noted on the drawings.

C. Duct sizes are indicated in the drawings. Where the duct sizes are indicated in both the power one-line/riser diagrams, and the panel/panelboard/switchboard/conduit size schedules/tables, the duct sizes indicated in the power one-line/riser diagrams shall take precedence. Additionally, where a ductbank section is provided in the drawings, the conduit size/quantity indicated in the ductbank section shall supersede the conduit size/quantity indicated in the power one-line/riser diagrams, and the panel/panelboard/switchboard/conduit size schedules/tables, for the underground portion of the conduit. Where the aboveground and underground conduit size/quantity do not match, provide an aboveground junction box (size/type per NEC and the contract documents) to transition from the aboveground to the underground conduit.

3.2 EARTHWORK

A. Excavation and Backfill: Do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.

D. Cut and patch existing streets, roads, driveways, parking lots, and paved areas in the path of underground ducts and utility structures. Repair existing streets, roads, driveways, parking lots, and paved areas after underground ducts and utility structures have been constructed/installed. The repaired streets, roads, driveways, parking lots, and paved areas shall match the adjacent streets, roads, driveways, parking lots, and paved areas.

E. Remove, re-install and repair as required, existing fences, sign posts, walls or structures that are in the path of underground ducts and utility structures.

3.3 DUCT INSTALLATION

A. Burial Depth:
1. Direct buried duct or ductbanks: All direct buried duct or ductbanks shall have a minimum of 36" of cover from the top of the duct or ductbank to finished grade, unless otherwise noted on the drawings.
2. Concrete encased ducts or ductbanks: All concrete encased duct or ductbanks shall have a minimum of 36" of cover from the top of the duct or ductbank to finished grade, unless otherwise noted on the drawings.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes or handholes to drain in both directions.

C. Where new ducts/ductbanks cross existing underground utilities, comply with the minimum cover requirements and minimum separation requirements indicated in the contract documents. Provide supports under the new ducts/ductbanks and existing underground utilities as required. The new duct/ductbanks shall be installed below the existing underground utilities, unless otherwise noted and except as follows:
1. The new duct/ductbanks may be installed above the existing underground utilities where ALL of the following conditions are met:
   a. Where it is installed, the new duct/ductbanks comply with the minimum cover requirements and minimum separation requirements indicated in the contract documents.
   b. Adequate supports are provided for the new duct/ductbanks such that it does not add weight onto the existing underground utilities.
   c. There will be no damage to the existing underground utilities.

D. Where new ducts/ductbanks cross other new ducts/ductbanks, comply with the minimum cover requirements and minimum separation requirements in the contract documents. The new ducts/ductbanks shall be installed above and below each other as required to comply with the minimum cover requirements and minimum separation requirements indicated in the contract documents. Provide supports under the new ducts/ductbanks as required.

E. Do not damage existing underground utilities and structures. Any damage caused by the contractor to existing underground utilities and structures shall be repaired by the contractor at no cost to the owner.

F. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends, both horizontally and vertically, at other locations, unless otherwise noted.

G. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

H. Provide duct sealing compound where underground ducts and ductbanks stub up at utility poles/transformers and where underground ducts and ductbanks enter buildings. Duct sealing compound shall provide a watertight seal inside the ducts and ductbanks. Where duct sealing compound is in contact with wiring that is furnished and/or installed by the utility company, product data of the duct sealing compound shall be submitted to the utility company for their review/approval prior to its use.

I. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

J. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
   1. Provide pulling cord in all unused or spare ducts.

K. Duct Entrances to Manholes and Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

   1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Grout end bells into structure walls from both sides to provide watertight entrances.

L. Building Wall Penetrations: Install conduit penetrations of building walls as specified in Specification Section "Common Work Results for Electrical."

M. Concrete-Encased Ducts:
   1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature. Where there are multiple sizes of conduit in a ductbank, provide spacers and spacer accessories to accommodate the conduit.
   2. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   3. Excavate trench bottom to provide firm and uniform support for ducts.
   4. Place and compact bedding course on trench bottoms. Use satisfactory soil, free of particles larger than 1 inch in any direction, as the compact bedding course. Depth of bedding course shall be not less than 6".
   5. Concreting Sequence: Pour each run of envelope between manholes, handholes or other terminations in one continuous operation.

      a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.

b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.

6. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
7. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
8. Comply with all of the following separation requirements, unless otherwise noted:
   a. Provide a minimum of 12" separation between 600V power or communications ducts and foreign structures (including, but not limited to, gas, water, sanitary and oil pipes).
   b. Provide a minimum of 12" separation between 600V power or communications ducts and medium voltage (>600V) duct/wiring.
   c. Provide a minimum of 6" separation between 600V power ducts and communications (including, but not limited to, telephone and cable tv) ducts.
   d. Provide a minimum of 3" separation between 600V power ducts and other 600V power ducts.
   e. Provide a minimum of 3" separation between communication ducts and other communication ducts.
   f. Comply with the minimum separation requirements of the Utility Companies. Coordinate with the Utility Companies as required.
9. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
10. Warning Tape: Bury warning tape above all concrete-encased ducts. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 36 inches. Space additional tapes 12 inches apart, horizontally. Depth of warning tape shall be 12" below finished grade.

N. Direct-Buried Ducts:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature. Where there are multiple sizes of conduit in a ductbank, provide spacers and spacer accessories to accommodate the conduit.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for ducts.
4. Place and compact bedding course on trench bottoms. Use satisfactory soil, free of particles larger than 1 inch in any direction, as the compact bedding course. Depth of bedding course shall be not less than 6".
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction.

6. Comply with all of the following separation requirements, unless otherwise noted:
   a. Provide a minimum of 12" separation between 600V power or communications ducts and foreign structures (including, but not limited to, gas, water, sanitary and oil pipes).
   b. Provide a minimum of 12" separation between 600V power or communications ducts and medium voltage (>600V) duct/wiring.
   c. Provide a minimum of 12" separation between 600V power ducts and communications (including, but not limited to, telephone and cable tv) ducts.
   d. Provide a minimum of 3" separation between 600V power ducts and other 600V power ducts.
   e. Provide a minimum of 3" separation between communication ducts and other communication ducts.
   f. Comply with the minimum separation requirements of the Utility Companies. Coordinate with the Utility Companies as required.
7. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated.
8. Warning Tape: Bury warning tape above all direct buried ducts. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 36 inches. Space additional tapes 12 inches apart, horizontally. Depth of warning tape shall be 12" below finished grade.
9. Concrete encasement at bends and 90 degree elbows: All bends and 90 degree elbows shall be concrete encased with a minimum of 3" thick of 3000 psi concrete at 28 days.

O. Provide underground-line warning tape above all direct buried and concrete encased ducts.

P. Excavation for Utility Trenches:

1. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of ducts and ductbanks.

Q. Utility Trench Backfill:

1. Place backfill on subgrades free of mud, frost, snow, or ice.
2. Backfill material shall be free of particles larger than 1 inch in any dimension.
3. Carefully compact initial backfill under conduit haunches and compact evenly up on both sides and along the full length of conduit to avoid damage or displacement of conduit.
4. Backfill voids while installing and removing shoring and bracing.
5. Backfill in layers not more than 4 inches for material compacted by hand operated tampers.
6. Compact soil material to not less than the following percentage of maximum dry unit weight according to ASTM D698:
   a. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

R. Ducts and ductbanks shall be made watertight.

S. Bending radius of ducts shall be selected to minimize wire or cable pulling tensions. Do not exceed the maximum pulling tension of the wire or cable manufacturer. Coordinate with wire or cable manufacturer.

T. Provide pull wires in all empty ducts.

U. Underground conduit, ducts, or ductbanks shall not be installed under concrete footings, piers, or other load bearing structures of the building. Additionally, these items shall not be located

within a 45 degree zone that extends downwards and outwards from the bottom outer edge of the load bearing structures.

V. Where ducts run under bollards or structural grade beams located between load bearing structures (including, but not limited to, concrete footings, piers, etc.) of buildings, comply with the following:
1. Increase the depth of the ducts to provide a minimum of 12" clearance between the top of the ducts and the bottom of the bollard or structural grade beam.
2. For Direct-Buried Ducts: Provide concrete encasement. Concrete encasement shall be a minimum of 3" thick on the sides, and 12" thick at the top and bottom, of the ducts. Concrete encasement shall extend a minimum of 3' before and after the bollard or structural grade beam. Concrete shall be 3000 PSI at 28 days.
3. For Concrete-Encased Ducts: Increase the thickness of the concrete encasement to a minimum of 12" thick at the top and bottom. Concrete encasement shall extend a minimum of 3' before and after the bollard or structural grade beam. Concrete shall be 3000 PSI at 28 days.

W. Where the burial depth of a duct is indicated in the Contract Documents, the indicated depth is the shortest distance measured between a point on the top surface of the duct, and the top surface of finished grade, concrete, or similar cover.

X. Where an underground duct penetrates an exterior wall below grade, and enters a room that is located below grade, the wall penetration shall not be located above any electrical equipment, unless otherwise noted.

3.4 INSTALLATION OF PRECAST CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.

2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.

3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, 6" deep minimum, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole and Handhole Frame: Set frames flush with finished grade.

C. Manhole and Handhole Access: Circular opening in manhole or handhole roof; sized to match cover size.

1. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole or handhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

D. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.

3.5 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support handhole/box on a level bed of crushed stone or gravel, 6" deep minimum, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth. Where the handhole/box manufacturer requires a different type of stone/gravel, or requires a greater depth of stone/gravel, comply with the manufacturer's recommendations.

C. Elevation: Cover surface will be flush with finished floor or finished grade.

D. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. For solid bottom handholes, provide a 1" diameter hole at the bottom of the handhole, to allow water to drain through.

F. Install handholes and boxes in accordance with the manufacturer's recommendations, so that the installed handholes and boxes comply with the load ratings required by the contract documents.

3.6 TEST PIT EXCAVATION

A. Provide test pits where the new underground ducts will cross with the location of the existing underground utilities and structures. Coordinate location of underground ducts, utilities and structures with the plans, the drawings provided by the utility locator contractor, and field conditions.

B. The test pits shall be used to determine the depth of existing underground utilities and structures where these utilities and structures are located within the depth of the test pits.

C. Depth of test pit shall be as required to determine there is no conflict between the new and existing underground ducts, utilities and structures. Minimum depth and separation requirements for the new underground ducts are indicated in the contract documents.

D. Upon completion, the test pit shall be backfilled, compacted, repaired, and the site returned to the original condition.

E. Perform test pit excavation prior to installing underground conduit, manholes/handholes or other underground structures.

F. Any damage to existing underground utilities and structures due to the test pit excavation shall be repaired by the contractor at no cost to the owner.

G. Coordinate depth and routing of ductbank with the results of the field investigation.

3.7 LOCATING EXISTING UNDERGROUND UTILITIES

A. The drawings do not show all the existing underground utilities. Also, the existing underground utilities shown on the drawings are shown in their approximate locations only. The contractor is

responsible for determining the existing underground utilities and their exact location for the areas where he will be working.

B. Before starting any work, hire the services of a Utility Locator contractor to determine the locations of existing underground utilities in the following areas:
   1. Where underground ducts are being installed
   2. Where concrete foundations are being installed for various equipment and structures
   3. Where any underground equipment or structures are being installed
   4. Where light poles and light bollards are being installed
   5. Where handholes and manholes are being installed
   6. Where the existing grade is being lowered
   7. Where there is excavation or any other earthwork

C. Location of existing underground utilities shall be marked up on the drawings.

D. The location of existing underground utilities shall be marked on the ground in the field.

E. Coordinate depth and routing of ductbank with the results of the field investigation.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

   1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
   2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes and handholes, including sump. Remove foreign material.

C. Do not damage the ducts during cleaning.

END OF SECTION

SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Comply with 29 CFR 1910.145.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:

1. Power Circuits: Black letters on an orange field.
2. Instrumentation and Control Circuits: Black letters on a yellow field.
3. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

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

2.5 INSTRUCTION SIGNS

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

2.6 EQUIPMENT IDENTIFICATION LABELS

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

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb, minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

2.8 TRACER WIRE

A. Tracer wire shall have the following features:
1. UL Listed
2. Suitable for direct burial in earth
3. Suitable for directional drilling applications.
4. Conductor material, size and strength selected to withstand pulling tensions
5. Shall have abrasion resistant insulation
6. 600V rated

PART 3 - EXECUTION

3.1 APPLICATION

A. Power-Circuit Conductor Identification: For conductors No. 4/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use write-on tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

B. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use marker tape. Identify each ungrounded conductor according to source and circuit number.

C. Locations of Underground Lines: Provide underground-line warning tape for direct buried and concrete encased ducts or ductbanks.

D. All receptacles, starters, disconnects, and drop cords (receptacles and lights) shall be labeled with its associated circuit number.

E. All panelboards shall be labeled with the circuit number associated with the feeder breaker that supplies power to it.

F. All equipment with integral disconnects shall be labeled with its associated circuit number.

G. All fire alarm control panels and fire alarm remote booster power supplies shall be labeled with its associated circuit number.

H. Warning Labels for Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
2. Provide a sign/label on panelboards, receptacles, controller and other equipment that are fed from the generator as follows: "FED FROM GENERATOR THRU ATS-xxx", where xxx is the label of the transfer switch.

3. Provide a "BUILDING FEEDER DISCONNECT" label for each building feeder disconnect at the building. Source of feeder shall also be indicated.
4. Where the removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating: SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCES(S) IS ENERGIZED.

I. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Adhesive film label with clear protective overlay

2. Equipment to be labeled includes, but is not limited to, the following:

   a. All power distribution equipment (including, but not limited to, panelboards, disconnects, breakers, transformers, electrical cabinets/enclosures, etc.)

3. All power distribution equipment (including, but not limited to, panelboards, disconnects, breakers, transformers, electrical cabinets/enclosures, etc.) shall be permanently marked with a label to indicate where its power originates from. The label on each equipment shall be "FED FROM YYY", where "YYY" is the name of the equipment where the power originates from.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
2. Colors for 208/120-V and 240/120V Circuits:

   a. Phase A: Black.

b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: White

3. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral: Gray

4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 12 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 36 inches overall.

G. Tracer wire:
1. Do not exceed the maximum pulling tensions of the tracer wire.
2. Test the tracer wire for continuity.

END OF SECTION

SECTION 26 05 73 - POWER SYSTEMS ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes computer-based, Fault-Current Study, Coordination Study, Overcurrent Protective Device Setting, and Arc Flash Hazard Analysis. Protective devices shall be set based on results of the protective device coordination study.

B. "Power distribution equipment", in this specification section, shall mean all equipment connected to service and feeder wiring, including but not limited to, switchboards, panelboards, transformers, generators, transfer switches, and feeder switches/enclosed circuit breakers.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Provide submittals for the following:

1. Fault-Current Study
2. Coordination-study input data, including completed computer program input data sheets.
3. Study and Equipment Evaluation Reports.
4. Coordination-Study Report.
5. Overcurrent Protective Device Setting
6. Arc-Flash Hazard Analysis

E. The studies shall be based on the equipment submitted for review, in the power distribution equipment submittals. The studies shall use the manufacturer and model numbers indicated in the power distribution equipment submittals. The power distribution equipment submittals shall be submitted at the same time as the submittals for the power systems analysis. If they are not submitted at the same time, the submittals shall be rejected.

F. Fault-Current Study, Coordination Study, Overcurrent Protective Device Setting, and Arc Flash Hazard Analysis shall be sealed and signed by a Professional Electrical Engineer that is licensed in the State of Maryland.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

PART 3 - EXECUTION

3.1 APPLICATION

A. Provide Fault-Current Study, Coordination Study, Overcurrent Protective Device Setting, and Arc Flash Hazard Analysis for the following:
1. All new power distribution equipment
2. Where the project includes existing to remain equipment:
   a. The first existing power distribution equipment located downstream from new power distribution equipment

b. Existing power distribution equipment which are relocated.
c. The first existing power distribution equipment located downstream from existing power distribution equipment which are relocated
d. New circuit breakers or other overcurrent protective devices installed in existing equipment (including, but not limited to, existing switchgear, existing panelboards, etc.), which feed new power distribution equipment

B. Provide Arc-flash labels on all equipment included in the Arc Flash Hazard Analysis.

C. The contractor shall obtain the latest fault current information from the Electric Utility. The fault current information shall be used in the studies.

D. Where the project includes existing to remain equipment, the contractor shall obtain information regarding existing equipment ratings, existing wire size/lengths, and other information as required to perform the power systems analysis required by the contract documents. The contractor shall field survey and verify existing conditions as required.

3.2 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.3 FAULT-CURRENT STUDY

A. Contractor shall coordinate with the electric utility and get the available fault current from the electric utility. Use the actual available fault current from the utility.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
2. Low-Voltage Fuses: IEEE C37.46.
3. Circuit Breakers: IEEE C37.13.

E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.4 COORDINATION STUDY

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical distribution system diagram showing the following:

    a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
    b. Circuit-breaker and fuse-current ratings and types.
    c. Relays and associated power and current transformer ratings and ratios.
    d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    e. Generator kilovolt amperes, size, voltage, and source impedance.
    f. Cables. Indicate conduit material, sizes of conductors, conductor insulation, and length.
    g. Busway ampacity and impedance.
    h. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Magnetic inrush current overload capabilities of transformers.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Ratings, types, and settings of utility company's overcurrent protective devices.
    e. Special overcurrent protective device settings or types stipulated by utility company.
    f. Time-current-characteristic curves of devices indicated to be coordinated.
    g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

B. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

C. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

D. Comply with IEEE 242 recommendations for fault currents and time intervals.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:

   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.

3. Completed data sheets for setting of overcurrent protective devices.

3.5 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.

B. Perform the following device setting and prepare reports:

1. Adjust devices according to recommendations in NETA ATS.

3.6 ARC-FLASH HAZARD ANALYSIS

A. The Arc-Flash Hazard Analysis shall be performed with the aid of computer software intended for this purpose in order to calculate Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances.

B. The Arc-Flash Hazard Analysis shall be performed in conjunction with a short-circuit analysis and a time-current coordination analysis.

C. Results of the Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum arc flash conditions.

E. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

F. The Arc-Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584, the IEEE "Guide for Performing Arc-Flash Calculations".

G. Labeling on equipment shall be in compliance with the National Electrical Code and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.

H. Furnish and install the arc flash labels on all equipment included in the arc flash hazard analysis.

END OF SECTION

SECTION 26 09 43 - LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. Section includes a networked lighting control system which includes, but is not limited to, the following components:
   1. System Software Interfaces
      a. Management and Visual Interface
      b. Historical Database and Analytics Interface
   2. System Backbone and Integration Equipment
      a. System Controller
   3. Lighting Control Devices

1.3 SUBMITTALS

A. Submittals shall include the following items:
   1. Bill of Materials for all components of the Lighting Control System
   2. Product Specification Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.
   3. Plan drawings showing locations of all lighting control devices and all cables connecting the devices to each other and other devices.
   4. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.
   5. Other Diagrams and Operational Descriptions as needed to indicate system operation or interaction with other system(s).
   6. Contractor Startup/Commissioning Worksheet which shall be completed by the contractor prior to factory start-up
   7. Service Specification Sheets indicating general service descriptions, including startup, training, post-startup support, and service contract terms.
   8. Hardware and Software Operation Manuals.
   9. Color selection chart for devices/equipment

B. Submittal drawings, details, and diagrams
   1. Prior to installation of lighting control devices/equipment and lighting fixture/luminaires, provide 1/8" = 1'-0" scaled plan drawings, details, and wiring diagrams; which show locations of all devices/equipment/fixtures/luminaires, with all device addresses, wired network control zones, symbols, power/control wiring, mounting details, and other information indicated. All equipment that require line voltage power (120V or 277V) shall be indicated on the plan drawings. At the completion of the construction, this drawing shall be updated with as-built information (including, but not limited to, exact location of all devices/equipment/fixtures/luminaires).

2. Prior to installation of lighting control devices/equipment and lighting fixture/luminaires, provide 1/8" = 1'-0" scaled plan drawings, which show coverage patterns of the occupancy sensors. The coverage patterns shall indicate which areas in each room (in this specification section, "room" shall include, but not be limited to, corridors and all spaces inside the building) will trigger occupancy detection, by the occupancy sensor. The contractor's bid price shall include providing additional occupancy sensors as required, to have complete occupancy detection for all rooms, where there is at least one occupancy sensor indicated in the plan drawings.

C. Prior to the demonstration and training, provide copies of the training materials (power point slide presentations, etc.)

D. Provide the following closeout submittals:
1. Project Record Documents: Accurately record the actual locations of Products.
2. Operating and maintenance manuals.
3. Operating Instructions: Document training by furnishing a sign-in sheet with a description on the training provided, instructors name and organization and those who received training.
4. Submit software database file with desired device labels and notes completed.
5. As-built drawings, details, and wiring diagrams

E. Provide field quality control test reports.

F. Field technician qualifications

G. Commissioning reports and commissioning agent qualifications.

H. Attendance sheet from the demonstration and training

1.4 QUALITY ASSURANCE

A. Product Qualifications
1. System electrical components shall be listed or recognized by a nationally recognized testing laboratory (e.g., UL, ETL, or CSA) and shall be labeled accordingly; and, shall be suitable for the intended use and location.
2. System shall be listed as qualified under DesignLights Consortium Networked Lighting Control System Specification V2.0.
3. System luminaires and controls are certified by manufacturer to have been designed, manufactured and tested for interoperability.
4. All components shall be subjected to 100% end of line testing prior to shipment to the project site to ensure proper device operation.
5. All components and the manufacturing facility where product was manufactured must be RoHS compliant.

B. Installation and Startup Qualifications
1. System startup shall be performed by qualified personnel approved or certified by the manufacturer.

1.5 WARRANTY

A. Provide the following warranties in addition to any warranties specified elsewhere in the contract documents:

1. The manufacturer shall provide a minimum two-year warranty on all devices and equipment. Warranty coverage shall begin on the date of substantial completion. The warranty shall cover repair or replacement any defective products within the warranty period.

1.6 COORDINATION

A. Coordinate the lighting control system to all other devices, equipment and systems to which it connects to. All input/output/communications interfaces/modules shall be compatible and suitable for use with each other.

B. Coordinate the names/identification/labels used by the lighting control system software/cables, with the actual room/area identification tags provided in the field.

C. Coordinate programming of the lighting control system (including, but not limited to, time delay settings, min/max light level settings, time schedules, etc.) with the owner prior to programming.

D. Coordination with the IT (Information Technology) Network Infrastructure
   1. Coordinate with the IT Network System Integrator and secure all required network connections to the IT network infrastructure.
   2. Provide all network infrastructure requirements of the lighting control system to the IT Network System Integrator.

E. Coordinate line voltage power (120V through 277V) requirements prior to starting any work to ensure that power is provided to all equipment. The contractor shall provide line voltage power to all equipment that require it, in accordance with the manufacturer's recommendations and NEC requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. The Acuity Controls nLight Lighting Control System is the basis-of-design. Provide Acuity Controls nLight Lighting Control System or approved equal.

2.2 GENERAL

A. The contractor shall provide all labor, software, programming, materials, equipment, hardware, mounting, wiring, conduit, junction boxes, power supplies, transformers, batteries, equipment enclosures (all equipment shall have enclosures), and accessories as required for a complete and fully operational system. The contractor shall provide all startup and testing as required, in order to confirm that the system operates in accordance with the contract documents. The system shall comply with all applicable codes, the manufacturer's recommendations, and the requirements of the authorities having jurisdiction.

B. Where licenses are required to install, operate, and maintain the system, provide a minimum of 2 licenses, except where more licenses are required elsewhere in the contract documents, in which case, the larger quantity shall apply. Each license shall be capable of being used locally (at the building), or remotely (in remote facility through the internet).

2.3 SYSTEM PERFORMANCE REQUIREMENTS

A. System Architecture
1. System shall have an architecture that is based upon three main concepts: (a) networkable intelligent lighting control devices, (b) standalone lighting control zones using distributed intelligence, (c) system backbone for remote, time based and global operation between control zones.
2. The system shall be capable of providing individually addressable switching and dimming control of the following: networked luminaires, control zones to include multiple switch legs or circuits, and relay and dimming outputs from centralized panels to provide design flexibility appropriate with sequence of operations required in each project area or typical space type.
3. Lighting control zones shall be capable of being networked with a higher level system backbone to provide time based control, remote control from inputs and/or systems external to the control zone, and remote configuration and monitoring through a software.
4. All system devices shall support remote firmware update, such that physical access to each device is not necessary, for purposes of upgrading functionality at a later date.
5. System shall be capable of "out of box" sequence of operation for each control zone. Standard sequence is:
   a. All switches control all fixtures in a zone
   b. All occupancy sensors automatically control all fixtures in the control zone with a default timeout.

B. Wired Networked Control Zone Characteristics
1. Following proper installation and provision of power, all networked devices connected together with low voltage network cable shall automatically form a functional lighting control zone without requiring any type of programming, regardless of the programming mechanism (e.g., software application, handheld remote, pushbutton). The "out of box" default sequence of operation is intended to provide typical sequence of operation so as to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.
   a. System shall be able to automatically discover all connected devices without requiring any provisioning of system or zone addresses.

C. System Integration Capabilities
1. The system shall have the hardware (interface/converter/connector module/card/feature) and software that provides it with the capability of interfacing with third party building management systems (BMS) to support two-way communication using the industry standard BACnet/IP or BACnet/MSTP protocols.

D. The lighting control system shall be capable of being remotely controlled by the Lighting Control System software, either through the local area network, or remotely through the internet. Software shall be password protected.

2.4 SYSTEM SOFTWARE INTERFACES

A. General:
1. Provide Lighting Control System software that shall allow for remote control/monitoring of the lighting control system. The software shall be password protected.

B. Management Interface
1. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.

2. Management interface must be compatible with industry-standard web browser clients, including, but not limited to, Microsoft Internet Explorer®, Apple Safari®, Google Chrome®, Mozilla Firefox®.
3. All system software updates must be available for automatic download and installation via the internet.

C. Historical Database and Analytics Interface
1. System shall provide a browser-based trending and monitoring interface that stores historical data for all occupancy/daylight sensors and lighting loads. Additionally, the system shall upload that data to a cloud based server.

D. All lighting control devices can be programmed and controlled over the internet. Password protection shall be provided to prevent unauthorized access.

2.5 LIGHTNG CONTROL DEVICES/EQUIPMENT

A. GENERAL
1. Occupancy sensors, switches and other lighting controls which are visible to the public shall be white in color, unless otherwise noted.
2. Where option code "LT" is required by the contract documents for switches, daylight/occupancy sensors and power packs, the switches/sensors/power packs which have this option code shall be suitable for low temperature/high humidity.

B. SYSTEM CONTROLLER
1. Provide NLIGHT NECY (ECLYPSE) model series with the following features:
   a. BACnet/IP & MS/TP Capability
      1) The lighting control system shall be controlled through the IT/computer network and not via BACnet. However, BACnet capability shall be provided for future use.
   b. Provide touchscreen interface with power supply
   c. Provide ethernet port for connection to the IT/computer network
   d. Provide hardware/software to allow control of the lighting control system through the local area network and through the internet.
   e. Provide Sensorview Software and other add-ons/upgrades as required to allow control of the lighting control system through the local area network and through the internet.
   f. Provide Wi-Fi Adapter
   g. Suitable for use with 120-277VAC branch circuits
   h. Provide additional features are required to comply with the requirements indicated in the contract documents.
   i. Provide NEMA 1 Enclosure. Enclosure dimensions shall not exceed: 15" high x 15" wide x 5" deep.
2. System Controller shall be a multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
3. System Controller shall perform the following functions:
   a. Facilitation of global network communication between different areas and control zones.
   b. Time-based control of downstream wired and wireless network devices.
   c. Linking into an Ethernet network.
   d. Connection to various software interfaces, including management interface, historical database and analytics interface, visualization interface, and personal control applications.
4. System Controller shall not require a dedicated PC or a dedicated cloud connection.

5. Device shall automatically detect all networked devices connected to it, including those connected to wired and wireless communication bridges.
6. Device shall have a standard and astronomical internal time clock.
7. Shall be capable of connecting to the customers Local Area Network (LAN) via IEEE 802.11.x Wireless and IEEE 802.3 Wired connection.
8. System Controller shall support BACnet/IP and BACnet/MSTP protocols to directly interface with BMS without the need for additional protocol translation gateways.
   a. BACnet/MSTP shall support a minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.
   b. BACnet/MSTP shall support 9600 to 115200 baud.
   c. System Controller shall be BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.
   d. System controller must support BACnet/IP Broadcast Management Device (BBMD) and Foreign Device Registration (FDR).

C. COMMUNICTIONS BRIDGE
1. Provide NLIGHT NBRG 8-KIT model series with the following features:
   a. Device shall include power supply
   b. Plenum Rated
   c. Suitable for use with 120/277VAC branch circuits

D. LIGHTING RELAY PANEL
1. Provide NLIGHT ARP INTENCxx NLT Model Series (where "xx" is the number of relays) with FCR Type Relays and the following features:
   a. The quantity of relays shall not be less than the number of circuits controlled by the relay panel, plus 25% spare relays or plus 4 spare relays, whichever provides a larger quantity of relays. Each relay shall have the following features:
      1) Field configurable for 2-pole and 3-pole relays
      2) Electronic Ballast Rating: 16A at 120-347VAC
      3) Tungsten Rating: 20A at 120-277VAC
      4) Horsepower Rating: 2HP @ 120VAC, 3HP @240-277VAC
      5) Short Circuit Current Rating: 65kA @ 277/480VAC
   b. Communicates through the nLight network
   c. All relays include local manual override lever
   d. All relays are individually programmable
   e. Compatible with the associated branch circuit voltages
   f. Surface mounted
   g. Suitable for use with 120-277VAC branch circuits
   h. Provide a digital time clock, where the relay panel is standalone, is not connected to an nlight network, and is not controlled by an nlight system controller.
   i. Provide a voltage barrier to separate normal and emergency circuits where both types of circuits are run through the relay panel. Coordinate with the lighting plans as required.
   j. Provide additional features are required to comply with the requirements indicated in the contract documents.
   k. Provide NEMA 1 enclosure. Enclosure dimensions shall not exceed: 41" high x 21" wide x 7" deep

E. LOW VOLTAGE OUTDOOR PHOTOCELL WITH AASSOCAITED INTERFACE UNIT
1. Provide NLIGHT NIO PC KIT

F. PLUG LOAD CONTROL POWER PACK
1. Where NLIGHT NPP20 PL power packs are required by the contract documents, the power packs shall have the following features:
   a. Output rating: 120V, 20A general purpose
   b. Relay type: Latching

c. Plenum rated

G. RELAY POWER PACK
1. Where NLIGHT NPP16-D-EFP (dimming type), or NLIGHT NPP16-EFP (non-dimming type) power packs are required by the contract documents, the power packs shall have the following features:
   a. Plenum rated
   b. Suitable for use with 120-277VAC branch circuits
   c. Relay Type: Latching
   d. Output rating: 16A tungsten, standard ballast, general purpose; 1/2hp rated at 10V
   e. Relay type: Latching
   f. Includes fuse integrated to relay wirelead for protection from load faults

H. LOW VOLTAGE WALL MOUNTED OCCUPANCY SENSORS
1. Where NLIGHT NWV PDT 16-KIT occupancy sensors are required by the contract documents, the sensors shall have the following features:
   a. Designed for 8 to 10 foot high mounting in room corner
   b. Small motions (hand movements) up to 40 ft detectable by sensor
   c. Large motions (walking)up to 70 ft detectable by sensor
   d. Dual tech (PIR/Microphonics) detection

I. LOW VOLTAGE INDOOR DAYLIGHT SENSOR
1. Where NLIGHT NCM ADCX-RJB daylight sensors are required by the contract documents, the sensors shall have the following features:
   a. Provide automatic dimming control of lighting fixtures

J. LOW VOLTAGE SWITCH WITH INTEGRAL OCCUPANCY SENSOR
1. Where NLIGHT NWSX PDT LV-DX occupancy sensors are required by the contract documents, the sensors shall have the following features:
   a. Detects small motion up to 20 feet away
   b. Detects large motion up to 36 feet away
   c. Dual tech (PIR/Microphonics) detection

K. LOW VOLTAGE CEILING MOUNTED OCCUPANCY SENSOR
1. Where NLIGHT NCM PDT-9-RJB occupancy sensors are required by the contract documents, the sensors shall have the following features:
   a. Provides 12 foot radial coverage when mounted at 9 ft AFF
   b. 8 to 15 foot mounting heights provided 10 to 20 feet of radial coverage
   c. Dual tech (PIR/Microphonics) detection
2. Where NLIGHT NCM PDT-10-RJB occupancy sensors are required by the contract documents, the sensors shall have the following features:
   a. Provides 24 foot radial coverage when mounted at 9 ft AFF.
   b. 7 to 15 foot mounting hegihts provided 16 to 36 feet of radial coverage
   c. Dual tech (PIR/Microphonics) detection
3. Where NLIGHT NCM-6-RJB occupancy sensors are required by the contract documents, the sensors shall have the following features:
   a. Suitable fo ruse with 15 to 45 foot mounting heights
   b. Detects large motion (walking) up to 35 feet away
   c. PIR detection
4. Where option code "ADCX" is required by the contract documents, the sensors shall have the following additional features:
   a. Sensor shall have an integral photocell which provides automatic dimming control of lighting fixtures.

L. LOW VOLTAGE SWITCH WITHOUT OCCUPANCY SENSOR

1. Where NLIGHT NPODMA series switches are required by the contract documents, the switches shall have the following features:
   a. Provide switch controls in accordance with the contract documents.
   b. For dimming type switches, ON/OFF and RAISE/LOWER switch controls shall be provided for each group of lights controlled by the switch.
   c. For non-dimming type switches, ON/OFF switch controls shall be provided for each group of lights controlled by the switch.
2. Where NLIGHT NPOD TOUCH series switches are required by the contract documents, the switches shall have the following features:
   a. Includes touch screen
   b. Proximity screen sensor for auto "wake up"
   c. Controls up to 16 on/off/dim lighting channels
   d. Controls up to 16 scene controls
   e. Password protected

2.6 WIRING

A. All low voltage, power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring shall be Plenum Rated (UL Type CMP). Wires shall be sized and selected such that proper operation of the system is achieved. Excessive voltage drop that can adversely affect proper operation of any component in the system shall be avoided.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Provide junction boxes as required, in accordance with the NEC and the manufacturer's recommendations.

B. Wiring methods for low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring:
   1. In the succeeding paragraphs, "raceway" shall mean conduit; and, minimum conduit size shall be ¾", unless otherwise noted and except as follows:
      a. Where surface raceway is required elsewhere in the contract documents, "raceway" shall mean surface raceway.
   2. Wiring that is exposed, concealed inside walls/floor, or concealed above inaccessible ceilings:
      a. All wiring shall be installed in raceway.
   3. Wiring that is concealed above accessible ceilings:
      a. All wiring shall be installed in raceway, unless otherwise noted and except as follows:
         1) Raceway may be omitted where all of the following conditions are met:
            a) Wiring is used for Communications Circuits or Class 2 Circuits.
            b) Wiring is used in dry locations.
            c) Wiring is used in aboveground applications.
            d) Wiring is not subject to physical damage.
            e) Wiring is supported and secured at intervals which do not exceed 3 feet.
            f) Wiring is supported by hangers and supports from the building structure.
            g) Wiring is not laid on ceiling tiles.

h) Wiring is not fastened in a manner that puts tension on the wiring.
i) Wiring is plenum rated (UL Type CMP).
j) Wiring is supported by UL Listed Metal J-Hooks (with rounded edges and integral cable retainer metal clip) and secured together with plenum rated nylon straps or clamps (the use of stapes is prohibited).
k) Wiring is concealed above accessible suspended ceilings (this includes, but is not limited to, ceiling spaces above grid type ceilings with removable ceiling tiles).
l) Raceway is not required by the NEC.

C. Provide Category 6 data cable from the lighting control system to the network switches, to allow the lighting control system to be monitored and controlled through the local area network by a computer with the lighting control software (software provided by the contractor). Coordinate exact location of the network switches in the field. All work shall comply with the manufacturer's recommendations, the NEC, and the contract documents.

D. All junction box covers shall be painted CYAN.

E. Provide the following label on the network switch port used to communicate with the Lighting Control System: "LIGHTING CONTROL SYSTEM".

F. Adjust exact location of photocells, photocontrols, and photosensors in the field so that the best possible view of the sunlight is provided, and the manufacturer's installation recommendations are followed.

G. Adjust exact location of occupancy sensors so that any motion within the room or space is detected by the occupancy sensors, and the manufacturer's installation recommendations are followed.

H. All switches and pushbuttons shall be labeled as to which lights are being controlled. Unused switches and pushbuttons shall be labeled as "spare".

I. Adjust exact location of sensors so that their sensor coverage is not blocked by raceways, boxes, and other equipment.

J. Coordinate electrical power supply connection type with the equipment. Where the equipment requires a receptacle connection, provide a receptacle. Where the equipment requires a hardwired connection, provide a hardwired connection. Coordinate all work with the manufacturer and the installation manuals. All work shall comply with the NEC, the manufacturer's recommendations, and the contract documents.

3.2 INSTALLATION

A. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

B. Cables shall have a minimum separation of 12 inches from 120V or higher power wiring. Cables shall have a minimum separation of 12 inches from light fixtures.

C. All wall and floor penetrations shall be sleeved. All conduit and sleeve ends must have bushings to prevent chafing. Where a conduit or other through-penetration device is installed through a fire rated assembly, the opening around the sleeve and the hole through the sleeve shall be sealed with an Underwriters Laboratory approved fire rated sealant material after the cables have been installed.

D. Install cables without damaging conductors or jacket.

E. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

F. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
4. Monitor cable pulling tensions.

G. Install cables parallel and perpendicular to surfaces or structural members and follow surface contours where possible.

H. Wiring within Wiring Closets and Enclosures: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

I. Separation of Wires: Comply with TIA/EIA-569-A rules for separating unshielded copper telephone and data communication cabling from potential EMI sources, including electrical power lines and equipment.

J. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect panels.

K. Use splice and tap connectors compatible with media types.

L. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

M. In the communications equipment room, install a 5-foot- long service loop on each end of cable.

N. Cable support inside wiring closets, telecommunications closets, data closets:

1. Support horizontal and backbone cabling from the fire retardant plywood board in each closet.
2. Provide cable ties and cable tie mounts to support the horizontal and backbone cabling from the plywood board. Provide cable ties every 3".
3. Cable tie mount shall be manufactured by Panduit or approved equal and shall use galvanized steel screws as the mounting method. Cable tie mount shall be UL Recognized. Cable tie mount size shall be suitable for the cables being supported.

O. Install all devices and equipment in accordance with the manufacturer's requirements.

3.3 IDENTIFICATION

A. Identify system devices, equipment, components, wiring, cabling, and terminals. Comply with the requirements for identification specified in Specification Section "Electrical Identification". Comply with the identification requirements of the applicable codes.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:
   1. Walkthrough each room/area and confirm that each lighting control device (switch, occupancy sensor, etc.) can turn on the lights within the room/area.
   2. Confirm that each dimming control device can dim the lights from its minimum to maximum dimming level.
   3. Confirm that each photosensor used for dimming or on/off switching is capable of dimming the associated lights, and/or turning the associated lights on/off.
   4. Confirm that each time schedule used to turn the lights on/off controls the lights at the appropriate day/time.
   5. Test all the low voltage, data, and/or communications cables, using a cable to tester, and confirm with the lighting control system manufacturer that the cables meet all the criteria that are needed for a complete and fully operational lighting control system.

C. Prepare test and inspection reports.

D. Remove and replace items which failed the tests/inspections, and then re-test/re-inspect.

E. Prepare re-test and re-inspection reports.

3.5 SYSTEM STARTUP

A. Installation Procedures and Verification
   1. The contractor shall review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.
   2. The contractor shall install and connect the networked lighting control system components according to the manufacturer's installation instructions, wiring diagrams, the project submittals and plans specifications.
   3. The contractor shall be responsible for testing of all low voltage network cable included in the bid. The contractor is responsible for verification of the following minimum parameters:
      a. Wire Map (continuity, pin termination, shorts and open connections, etc.)
      b. Length
      c. Insertion Loss

B. Upon completion of installation by the installer, including completion of all required verification and documentation required by the manufacturer, the system shall be started up and programmed by an authorized representative of the manufacturer.
   1. Low voltage network cable testing shall be performed prior to system startup.

C. System start-up and programming shall include:
   1. Verifying operational communication to all system devices.
   2. Programming the network devices into functional control zones to meet the required sequence of operation.
   3. Programming and verifying all sequence of operations.
   4. Customization of owner's software interfaces and applications.

D. Initial start-up and programming shall occur on-site. Additional programming shall also occur on-site, unless otherwise noted and except as follows:

1. Additional programming may be done over the Internet, where all of the following conditions are met:
   a. The additional programming does not require physical access to the equipment and can be made through the internet.
   b. The contractor provides all the hardware, software, and other equipment as required to be enable to access the internet.

E. Startup shall be performed by factory trained field technician. Factory training certifications and technician qualifications shall be submitted for review/approval.

3.6 COMMISSIONING

A. Provide operational test of all lighting control devices and all time based controls. Make sure that all lighting control devices and time based controls operate in accordance with the manufacturer's recommendations and the contract documents.

B. Submit commissioning report. The report shall be signed/dated by the commissioning agent. The commissioning agent shall be factory trained by the lighting control system manufacturer. Factory training certifications and commissioning agent certifications shall be submitted for review/approval.

3.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for five (5) years. Technical support shall include the following:
   1. Toll free technical support via phone
   2. Technical support via the internet

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within five (5) years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

   1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION AND TRAINING

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

B. Demonstration and training shall include the following:
   1. One day (lasting not less than 8 hours) to meet with the owner, and discuss programming requirements/preferences, prior to final programming of the system. The contractor shall comply with the programing requirements/preferences of the owner.
   2. One day (lasting not less than 8 hours) to meet the owner (after final programming of the system), and train the owner in the use/maintenance of the system. A report showing how the lighting control system was programmed, shall be distributed during the training. The System Supplier shall provide documented formalized instruction for the owner, detailing the proper operation and maintenance of the installed System. The instruction shall be presented in an organized and professional manner by a person factory trained

in the operation and maintenance of the equipment and who is also thoroughly familiar with the installation.

3. During the training, the instructor shall provide a laptop that is loaded with the system software, which allows the trainees to monitor and control the system through the network. At the end of the training, this laptop and all software installed on it, shall become the property of the owner, at no additional cost.
4. Demonstration and training shall show the owner how to change/program schedules, time delays, sensitivity settings, and switches. Demonstration and training shall show the owner how to replace broken switches, occupancy sensors, and photo/daylight sensors.

END OF SECTION

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Branch-circuit panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. MCB: Main Circuit Breaker

C. KAIC: Thousand Ampere Interrupting Capacity

D. Branch Breaker: A circuit breaker at a panelboard, that is located on the loadside of the Main Circuit Breaker or Main Lugs of that panelboard.

E. NEC: National Electrical Code

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes. Provide size/quantity for all wire lugs/terminals at the equipment.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

D. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

E. Field Quality Control Test Reports

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

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

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Service Conditions: NEMA PB 1, usual service conditions.

1.8 COORDINATION

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

Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate wire terminals/lugs at the equipment with the wires that are connected to it. Wire terminals/lugs shall be suitable for use with the wires that are connected to.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- or surface-mounted cabinets, as indicated on the drawings.

1. Rated for environmental conditions at installed location. See drawings for NEMA 250 enclosure type.
2. Finishes: Steel (unless otherwise noted), factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
3. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

B. Phase and Neutral, Buses:

1. Material: Copper, unless otherwise noted

C. Ground Buses:

1. Equipment Ground Bus: Copper. Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Main and Neutral Lugs: Mechanical type.
2. Ground Lugs and Bus-Configured Terminators: Mechanical type.

E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

F. Multi-Section Panelboards:

1. Multi-Section Panelboards shall have equal-height boxes and common trim.

2. Provide lugs, wiring, raceways, and other items as required to connect multi-section panelboards together. The ampacity of the lugs/wiring connecting multi-section panelboards together, shall not be less than the ampacity of the panelboard buses. All work shall comply with the manufacturer's recommendations and NEC requirements.

G. Panelboard Short-Circuit Current Rating:

1. Fully rated to interrupt symmetrical short-circuit current available at terminals, unless otherwise noted.

H. Where the Panel Schedules (the Panel Schedules are shown on the drawings) indicate that a 200% neutral is required; this shall mean that the panel shall have a neural bs that is rated at 200% of the phase bus, and is UL listed as suitable for non-linear loads. Neutral wire terminals/connectors shall be suitable for use with the wiring indicated in the drawings.

I. All service equipment shall have barriers in place, such that no uninsulated ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

2.2 DISTRIBUTION PANELBOARD

A. Manufacturers: Square D is the basis-of-design manufacturer. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work also include, but are not limited to, the following:
1. General Electric Company.
2. Siemens Energy & Automation, Inc.
3. Eaton

B. Panelboards: Comply with NEMA PB 1

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike. All panelboards shall have doors, and all doors shall have locks (provide a minimum of 3 keys per lock). All panelboards shall be keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.

D. All panelboards with service disconnects shall be UL listed as suitable for use as service equipment.

E. Dimensions of Panelboards shall not exceed the following:
1. Box Width: 44"
2. Box Depth: 9.5"
3. Enclosure Height: Varies based on the quantity of circuit breakers and spaces.

F. Basis-of-Design Distribution Panelboards:
1. Square-D Type I-LINE

2.3 BRANCH CIRCUIT PANELBOARD

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: Comply with NEMA PB 1

C. All panelboards with service disconnects shall be UL listed as suitable for use as service equipment.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Provide single door construction, made of cold-rolled steel. Door shall have concealed hinges, flush catch, and lock. Secure top and bottom of door to cabinet by slotted steel bolts. Release shall be by one-half turn with a screwdriver. All panelboards shall have doors, and all doors shall have locks (provide a minimum of 3 keys per lock). All panelboards shall be keyed alike.

1. Panelboards shall be equipped with "door within door" type trim. The entire front trim shall be hinged to the box, and a standard door shall be within the hinged trim cover.

F. Dimensions of 120/208V Panelboards shall not exceed the following:
   1. Box Width: 20"
   2. Box Depth: 5.75" except as follows:
      a. Where the panelboard has a main breaker or sub-feed breaker greater than 225A, the box depth shall not exceed 8.75"
   3. Enclosure Height: Varies based on the quantity of circuit breakers and spaces.

G. Dimensions of 277/480V Panelboards shall not exceed the following:
   1. Box Width: 20"
   2. Box Depth: 5.75" except as follows:
      a. Where the panelboard has a main breaker or sub-feed breaker greater than 250A, the box depth shall not exceed 8.75"
   3. Enclosure Height: Varies based on the quantity of circuit breakers and spaces.

H. Basis of Design Branch Circuit Panelboards:
   1. 120/208V Panels: Square-D Type NQ
   2. 277/480V Panels: Square-D Type NF

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (5-mA trip).
   3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      c. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment;
      d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      e. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
      f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
      g. Handle Clamp: The handle clamp shall prevent the circuit breaker handle from being manually switched to the OFF position. Handle clamp shall not prevent the

circuit breaker from tripping. Authorized personnel shall have the capability to remove the handle clamp.

h. Trip-free mechanism: allows breaker to trip even with the handle locked or held in the ON position.
i. Circuit breakers shall be suitable for reverse feed.
j. Auxiliary contact: indicates position of the breaker

C. Where the drawings or specifications indicate that a circuit breaker shall have adjustable LSI trip settings, this shall mean that the circuit breaker shall have an electronic trip unit, and that the following trip settings shall be field adjustable:
1. Long Time Pickup
2. Short Time Pickup
3. Instantaneous Pickup
4. Long Time Delay
5. Short Time Delay

D. Where the drawings or specifications indicate that a circuit breaker shall have adjustable LSIG trip settings, this shall mean that the circuit breaker shall have an electronic trip unit, and that the following trip settings shall be field adjustable:
1. Long Time Pickup
2. Short Time Pickup
3. Instantaneous Pickup
4. Ground Fault Pickup
5. Long Time Delay
6. Short Time Delay
7. Ground Fault Time Delay

E. Where the drawings or specifications indicate that a circuit breaker shall be 100% rated, this shall mean that the circuit breaker is UL listed as suitable for carrying 100% of rated current continuously.

F. Circuit breakers which incorporate ground fault protection shall have the following features:
1. Ground fault push-to-trip button
2. Ground fault trip indicator light

2.5 ENERGY REDUCTION MAINTENANCE SWITCH (ERMS) SYSTEM

A. The Energy Reduction Maintenance Switch (ERMS) System shall have the following features:
1. It shall have an ERMS. Turning on the ERMS shall reduce circuit breaker tripping time, and reduce arc energy in accordance with NEC requirements.
2. The ERMS shall have a blue indicator light.
3. The ERMS shall reduce the circuit breaker tripping time of the associated breaker. The breaker shall be suitable for use with the ERMS System.
4. The ERMS System shall include all control power breaker, power supply, contact blocks, padlock attachment, IO module, terminator, connectors, modules, cells, and associated wiring/conduit/accessories for a complete and fully operational system in accordance with the manufacturer's recommendations and NEC requirements. Any component of the ERMS System which does not fit inside the associated panelboard shall be installed in separate metal enclosure (size/type per NEC requirements) located as close as possible to the panelboard. Wiring/conduit shall be provided from the enclosure to the panelboard in accordance with the manufacturer's recommendations and NEC requirements.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Circuit breaker trip ratings are indicated in the drawings. Where circuit breaker trip ratings are indicated in both the power one-line/riser diagrams, and the panel/panelboard schedules, the circuit breaker trip ratings indicated in the power one-line/riser diagrams shall take precedence.

B. Provide circuit breakers with adjustable trip settings as indicated in the drawings, and as follows (comply with both the drawings and the requirements indicated below):

1. Circuit breakers which feed panelboards or transformers, and circuit breakers with a trip rating of 200A or more, shall have adjustable LSI trip settings. Adjustable ground fault settings shall also be provided where required elsewhere in the contract documents.

2. Circuit breakers which meet all of the following criteria shall have adjustable LSIG trip settings:

a. The circuit breaker is installed on an electrical system which has a phase to ground voltage of more than 150V. This includes, but is not limited, to circuit breakers installed on 277V to 480V electrical systems.

b. The circuit breaker trip rating is 1000A or more.

C. For circuit breakers with a trip rating of 1000A or less, comply with the following:
1. Provide a sensor plug or other module which limits the maximum trip current of the circuit breaker to1000A or less. The circuit breaker shall not be field adjustable to a trip rating higher than 1000A. For example, where the drawings show a 1000A breaker, provide a breaker with a sensor plug or other module which limits the breaker trip rating to 1000A. In no case shall the 1000A breaker be field adjustable to a trip rating greater than 1000A.

D. Where the panelboard has a 1200A main breaker or where the panelboard main breaker trip rating can be adjusted to 1200A or more, provide an ERMS System for the panelboard.

E. Panelboards shall be branch circuit panelboards, unless otherwise noted and except as follows:

1. Panelboards with bus or main breaker ratings greater than 400A shall be distribution panelboards.

2. Where the panelboard requirements (including, but not limited to, features, type, size, ampere rating, short circuit current rating, and quantity of breakers/buses/etc.) indicated in the contract documents cannot be met by a branch circuit panelboard, provide a distribution panelboard. Panelboards shall comply with the requirements indicated in the contract documents.

F. Provide a handle padlocking device for all breakers which feed the following equipment (see panel schedules): Electric hand dryers, ADA electric door openers, and electric vehicle charging stations.

G. Circuit breakers shall have the capability of accepting a handle clamp. The handle clamp shall prevent the circuit breaker handle from being manually switched to the OFF position. Handle clamp shall not prevent the circuit breaker from tripping. Authorized personnel shall have the capability to remove the handle clamp. Provide handle clamp for circuit breakers which feed the following items (see panel schedules):

1. Fire alarm control panels, fire alarm booster power supplies, or any 120V branch circuit that feeds fire alarm equipment.

H. Provide an auxiliary contract for all breakers which feed the following equipment (see panel schedules): Elevators

3.2 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount panelboard at one of the following mounting heights, unless otherwise indicated on the drawings:
1. Wherever the overall height of the panelboard is 5' or less, mount the panelboard such that the top of the panelboard enclosure is located at 6' above the finished floor.
2. Wherever the overall height of the panelboard is greater than 5', mount the panelboard such that the center of the grip of the operating handle of the top-most circuit breaker, when in the highest position, is not more than 6'-6" above the finished floor. Where the topmost circuit breaker position is a space for a future circuit breaker, assume that there is a circuit breaker mounted in the space for determining the mounting height of the panelboard.

C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

D. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

F. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

G. Comply with NECA 1.

H. Provide all necessary blocking, channels and other hardware for securing panelboards to wall, column, or other parts of building structure.

I. Spare circuit breakers and spaces for future circuit breakers shall be located towards the top of the panelboards.

J. Spare circuit breakers shall be turned off.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Specification Section "Electrical Identification."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Specification Section "Electrical Identification."

D. Service Equipment Label: Service equipment shall be NRTL labeled for use as service equipment.

3.5 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Engage a qualified testing agency and perform the following tests and inspections, and prepare test reports:

a. Perform each visual and mechanical inspection and electrical test stated in the NETA Acceptance Testing Specification. Certify compliance with test parameters.

1) Electrical tests are required for all panelboards. Visual and mechanical inspections are required on all panelboards.

b. In addition to the tests required in the NETA Acceptance Testing Specification, perform the tests below, except where the manufacturer of the equipment indicates in writing that the tests will damage the equipment being tested (coordinate with the equipment manufacturer as required):

1) After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
2) Provide insulation resistance testing for each panelboard bus
3) Provide primary current injection tests for all circuit breakers that have electronic trip units.
4) Provide primary current injection tests for all circuit breakers that have field adjustable long time, short time, or instantaneous trip settings.
5) Provide primary current injection tests for all service disconnects.
6) Provide primary current injection tests for all main circuit breakers.

2. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.

3. Remove and replace items which do not pass the tests. Test the replacement items.

3.7 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to maintain panelboards. Provide a minimum of 8 hours of training.

END OF SECTION

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Single and duplex receptacles, ground-fault circuit interrupters.
2. Single- and double-pole snap switches.
3. Device wall plates.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. PVC: Polyvinyl chloride.

D. Heavy Duty Grade: Industrial Grade

1.4 SUBMITTALS

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

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.

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

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Wiring Devices:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Mfg. Company Inc.
   c. Pass & Seymour/Legrand; Wiring Devices Div.

2.2 RECEPTACLES

A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.

B. Straight-Blade and Locking Receptacles: Heavy-Duty grade.

C. GFCI Receptacles: Straight blade, feed-through type; heavy-duty grade, with ground fault protection, test and reset pushbuttons; NEMA WD 6, duplex receptacle; Complies with UL 498 and UL 943. Design units for installation in a 2-3/4 inch deep outlet box without an adapter.

D. All 15 and 20 ampere receptacles in wet locations shall be UL listed as weather-resistant.

2.3 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.4 SWITCHES

A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.

B. Snap Switches: Heavy-Duty grade, quiet type.

2.5 WALL PLATES

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

1. Plate-Securing Screws: Stainless steel screws.
2. Material for Switches and Receptacles in Dry Locations: 0.035-inch-thick, satin-finished stainless steel, unless otherwise noted

3. Material for Receptacles in Wet Locations and Outdoors, or where the drawings indicate that the receptacle cover shall be weatherproof:
   a. Cast aluminum construction.
   b. Mounting screws and gaskets included for fast, easy installation onto surface mounted outdoor type boxes or flush-mounted wall boxes.
   c. Weatherproof while-in-unattended use with cover closed and plug inserted.
   d. Cover shall have provisions for padlocks.
   e. Depth of cover shall not exceed 3.5".
4. Material for Switches in Wet Locations and Outdoors, or where the drawings indicate that the switch cover shall be weatherproof:
   a. Cast aluminum construction
   b. Mounting screws and gaskets included for fast, easy installation onto surface-mounted outdoor type boxes or flush-mounted wall boxes.
   c. Cover shall have provisions for padlocks.
   d. Suitable for use in wet locations.
   e. Switch cover shall be O-Z/Gedney FS-1-WSCA for single gang boxes and FS-2-WSCA for two gang boxes, or approved equal.

2.6 FINISHES

A. Color:
   1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies level, plumb, and square with building lines.

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

C. Coordination with Other Trades:

   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Remove wall plates and protect devices and assemblies during painting.

D. Conductors:

   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

E. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
5. Tighten unused terminal screws on the device.
6. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

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

3.2 CONNECTIONS

A. Ground equipment according to Specification Section "Grounding and Bonding."

B. Connect wiring according to Specification Section "Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION

SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Cartridge fuses rated 600 V and less for use in switches, controllers and motor-control centers.

1.3 SUBMITTALS

A. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

a. Let-through current curves for fuses with current-limiting characteristics.
b. Time-current curves, coordination charts and tables, and related data.
c. Ambient temperature adjustment information.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from a single manufacturer.

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

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Bussman, Inc.
2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
3. Ferraz Shawmut, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Feeders: Class RK1, time delay, except as follows:
1. Class J Fuses shall be used where indicated on the drawings. Class J fuses shall be time delay type unless otherwise noted.
2. Class L Fuses shall be used where indicated on the drawings. Class L fuses shall be time delay type unless otherwise noted.

B. Motor Branch Circuits: Class RK1, time delay.

C. Other Branch Circuits: Class RK1, time delay, except as follows:
1. Class J Fuses shall be used where indicated on the drawings. Class J fuses shall be time delay type unless otherwise noted.
2. Class L Fuses shall be used where indicated on the drawings. Class L fuses shall be time delay type unless otherwise noted.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosed molded-case circuit breakers.
4. Enclosures.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. HD: Heavy duty.

C. RMS: Root mean square.

D. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current rating.
4. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
5. Provide size/quantity for all wire lugs/terminals at the equipment.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate wire terminals/lugs at the equipment with the wires that are connected to it. Wire terminals/lugs shall be suitable for use with the wires that are connected to.

1.8 EXTRA MATERIALS

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

1. Spares: For the following:
   a. Fuses for Fusible Switches:
      1) Provide 3 spare fuses for each fused switch rated 100A and higher.
      2) Provide 10% spare fuses for fuses rated less than 100A.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Available Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Siemens Energy & Automation, Inc.
4. Square D/Group Schneider.

B. Type HD, Heavy Duty Switch: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Provisions for padlocks: Fusible and non-fusible switches shall include provisions for being padlocked in the open or closed position.

D. Fusible switches shall be suitable for use with Class R fuses unless otherwise noted and except as follows:
1. Provide fusible switches with Class J fuses where indicated on the drawings.
2. Provide fusible switches with Class L fuses where indicated on the drawings.

E. Fusible switches shall have clips or bolt pads to accommodate specified fuses.

F. Short circuit rating of Type HD Fusible Switches when used with Class R, Class J, or Class L fuses shall not be less than 200,000A.

G. Conductor Connectors: Suitable for use with conductor material and sizes.

H. Voltage Rating:
1. Fusible switches: Switches shall be rated for 240V or 600V as indicated on the drawings.
   a. Where the drawings show a 208V switch (208V is the voltage of the circuit), provide a 240V switch.
   b. Where the drawings show a 480V switch (480V is the voltage of the circuit), provide a 600V switch.
2. Non-fusible switches: Switches shall be rated for 600V.
   a. Where 208V is indicated in the drawings, this is intended to show that the supplied voltage for the circuit is 208V. However, switch shall still be rated for 600V.
   b. Where 240V is indicated in the drawings, this is intended to show that the supplied voltage for the circuit is either 208V or 240V. However, switch shall still be rated for 600V.

I. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

J. All service equipment shall have barriers in place, such that no uninsulated ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

2.3 ENCLOSED MOLDED-CASE CIRCUIT BREAKERS

A. Available Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Siemens Energy & Automation, Inc.
4. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

C. Provisions for padlocks: Molded-Case Circuit-Breakers shall include provisions for being padlocked in the open or closed position.

1. When the breaker is padlocked in the closed position, the padlock shall not prevent the breaker from tripping due to overcurrent conditions.
2. Enclosed circuit breakers with NEMA 1 Enclosures that are required to be lockable shall have Handle Padlock Attachments.

D. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment;
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
6. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

E. Circuit Breaker Short-Circuit Current Rating:

1. Fully rated to interrupt symmetrical short-circuit current available at terminals.

F. Circuit breakers which incorporate ground fault protection shall have the following features:
1. Ground fault push-to-trip button
2. Ground fault trip indicator light

G. Where the drawings or specifications indicate that a circuit breaker shall have adjustable LSI trip settings, this shall mean that the circuit breaker shall have an electronic trip unit, and that the following trip settings shall be field adjustable:
1. Long Time Pickup
2. Short Time Pickup
3. Instantaneous Pickup
4. Long Time Delay
5. Short Time Delay

H. Where the drawings or specifications indicate that a circuit breaker shall have adjustable LSIG trip settings, this shall mean that the circuit breaker shall have an electronic trip unit, and that the following trip settings shall be field adjustable:
   1. Long Time Pickup
   2. Short Time Pickup
   3. Instantaneous Pickup
   4. Ground Fault Pickup
   5. Long Time Delay
   6. Short Time Delay
   7. Ground Fault Time Delay

I. Where the drawings or specifications indicate that a circuit breaker shall be 100% rated, this shall mean that the circuit breaker is UL listed as suitable for carrying 100% of rated current continuously.

J. All service equipment shall have barriers in place, such that no uninsulated ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

K. Enclosed circuit breaker dimensions shall not exceed the following:
   1. Enclosed Circuit Breakers rated 600A to 1200A: 53" high x 21" wide x 10" deep
   2. Enclosed Circuit Breakers rated 100A and less:19" high x 9" wide x 5" deep

2.4 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location. See drawings for NEMA 250 enclosure type.

2.5 IDENTIFICATION

A. Service Equipment Label: Service equipment shall be UL labeled for use as service equipment.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. All disconnects for elevators shall have an auxiliary contact to indicate switch position.

B. All Fusible and Nonfusible Switches shall be Type HD, Heavy Duty Switches.

C. Provide circuit breakers with adjustable trip settings as indicated in the drawings, and as follows (comply with both the drawings and the requirements indicated below):
   1. Circuit breakers which feed panelboards or transformers, and circuit breakers with a trip rating of 200A or more, shall have adjustable LSI trip settings. Adjustable ground fault settings shall also be provided where required elsewhere in the contract documents.
   2. Circuit breakers which meet all of the following criteria shall have adjustable LSIG trip settings:
      a. The circuit breaker is installed on an electrical system which has a phase to ground voltage of more than 150V. This includes, but is not limited, to circuit breakers installed on 277V to 480V electrical systems.
      b. The circuit breaker trip rating is 1000A or more.

D. For circuit breakers with a trip rating of 1000A or less, comply with the following:
   1. Provide a sensor plug or other module which limits the maximum trip current of the circuit breaker to1000A or less. The circuit breaker shall not be field adjustable to a trip rating higher than 1000A. For example, where the drawings show a 1000A breaker, provide a breaker with a sensor plug or other module which limits the breaker trip rating to 1000A. In no case shall the 1000A breaker be field adjustable to a trip rating greater than 1000A.

E. Mount equipment at one of the following mounting heights (provide independent freestanding supports for equipment as required), unless otherwise indicated on the drawings:
   1. Wherever the overall height of the equipment is 5' or less, mount the equipment such that the top of the equipment enclosure is located at 6' above the finished floor, unless otherwise noted and except as follows:
      a. Where the equipment is located on the roof, the top of the equipment may be lower, as long as all of the following conditions are met:
         1) The bottom of the equipment enclosure is not less than 24".
         2) The equipment is associated with mechanical units (including, but not limited to, roof top units, air handling units, exhaust fans, etc.) on the roof, and the top of the equipment is not less than the top of the associated mechanical unit.
   2. Wherever the overall height of the equipment is greater than 5', mount the equipment such that the center of the grip of the operating handle of the equipment disconnecting means, when in the highest position, is not more than 6'-6" above the finished floor.
      a. Where the equipment is located on the roof, the top of the equipment may be lower, as long as all of the following conditions are met:
         1) The bottom of the equipment enclosure is not less than 24".
         2) The equipment is associated with mechanical units (including, but not limited to, roof top units, air handling units, exhaust fans, etc.) on the roof, and the top of the equipment is not less than the top of the associated mechanical unit.

3.2 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Provide UL Listed fuse reducers as required

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components

B. Enclosure Nameplates: Label each enclosure

3.5 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Engage a qualified testing agency and perform the following tests and inspections, and prepare test reports:
   a. Perform each visual and mechanical inspection and electrical test stated in the NETA Acceptance Testing Specification. Certify compliance with test parameters.
      1) Electrical tests are required for switches and enclosed circuit breakers that are rated 100A and higher. Visual and mechanical inspections are required on all switches and enclosed circuit breakers.

   B. In addition to the tests required in the NETA Acceptance Testing Specification, perform the tests below, except where the manufacturer of the equipment indicates in writing that the tests will damage the equipment being tested (coordinate with the equipment manufacturer as required):
      1) After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch and circuit breaker, rated more than 100 amperes. Remove front panels so joints and connections are accessible to portable scanner.
      2) Provide primary current injection tests for all circuit breakers that have electronic trip units.
      3) Provide primary current injection tests for all circuit breakers that have field adjustable long time, short time, or instantaneous trip settings.
      4) Provide primary current injection tests for all service disconnects.
2. The testing agency shall coordinate with the manufacturer of the item being tested, and shall obtain copies of the installation/testing manuals. The testing agency shall not exceed the test voltage/current/duration limits indicated by the manufacturer.
3. Remove and replace items which do not pass the tests. Test the replacement items.

3.8 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to maintain switches/breakers. Provide a minimum of 8 hours of training.

END OF SECTION

SECTION 26 43 13 - SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This section describes the materials and installation requirements for Surge Protective Devices.

1.3 DEFINITIONS

A. SPD: Surge Protective Device

B. UL: Underwriter's Laboratories

1.4 SUBMITTALS

A. Submit complete product data on all the features and ratings of the devices, including, but not limited to, the following:
   1. Short Circuit Current Rating
   2. Voltage Protection Ratings for all modes
   3. Maximum Continuous Operating Voltage
   4. I-nominal rating (In)
   5. UL File Number
   6. UL Category Code
   7. Provide size/quantity for all wire lugs/terminals at the equipment.

B. Submittals shall include shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing all field connections and manufacturer's recommended wire and breaker sizes.

C. Field quality control test reports

1.5 COORDINATION

A. Coordinate SPD with the manufacturer of the protected equipment prior to purchase and installation of the SPD to ensure that the surge protector is suitable for its application. Items to coordinate, include, but are not limited to: equipment voltage, maximum continuous operating voltage, frequency bandwidth, and wire connections.

B. Coordinate wire terminals/lugs at the equipment with the wires that are connected to it. Wire terminals/lugs shall be suitable for use with the wires that are connected to.

C. Coordinate SPD with the breaker/circuit it will be connected to. The SPD shall be compatible and suitable for use with the associated breaker/circuit.

1.6 WARRANTY

A. Provide the following warranties in addition to any warranties specified elsewhere in the contract documents:
   1. The manufacturer shall provide a minimum ten-year warranty on all devices and equipment. Warranty coverage shall begin on the date of shipment. The warranty shall cover repair or replacement any defective products within the warranty period.

PART 2 - PRODUCTS

2.1 SURGE PROTECTIVE DEVICE

A. Provide Square D EMA model series with the following features:
   1. Modular parallel device
   2. Multi-stage suppression circuits consisting of field-proven, fast-acting metal oxide varistors (MOVs)
   3. A surge suppression path is provided for each mode, line-to-neutral (L-N), line-to-line (L-L), line-to-ground, and neutral-to-ground.
   4. Each surge suppression mode is individually fused and uses Thermal Cut-Off (TCO) circuitry to isolate the PSD and ensure shutdown in the event of MOV damage during severe overvoltages, even when operated on high-fault current power systems.
   5. A filter provides EMI/RFI noise attenuation.
   6. On-line diagnostics continuously monitor the device status, and LEDs signal a loss of a suppression circuit. An audible alarm with an enable/disable feature and dry contacts are included in the diagnostic package.
   7. Push-to-test on-line diagnostic display
   8. Front panel alarm with enable/disable switch
   9. Duty cycle tested (ANSI C62.41 C_{high}, 10kA, 20kV) 20,000 impulses
   10. High-energy parallel design for ANSI/IEEE C62.41 and C62.45 category B and C applications
   11. Short Circuit Current Rating: 200kA
   12. EMI/RFI filtering up to -42dB (100kHz to 100MHz)
   13. Sine Wave Tracking
   14. UL 1449 Listed
   15. UL 1283 Listed
   16. NEMA 1/3R/12 Enclosure
   17. Nominal Discharge Current Rating (In): 20kA
   18. Complies with UL96A and NFPA 780 requirements for surge protective devices used for lightning protection
   19. Surge Protective Device (SPD) Type 1. SPD Type 1 are defined by UL as follows:
      a. Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device.

B. Surge Capacity: 240 kA/phase, 120 kA line-neutral, 120 kA line-ground, and 120 kA neutral-ground, unless otherwise noted.

C. Enclosure dimensions and weight for SPD with integral disconnecting means shall not exceed 11.04" wide x 5.32" deep x 20.32" high, and 27 lbs, respectively.

D. Enclosure dimensions and weight for SPD without integral disconnecting means shall not exceed 11.04" wide x 5.32" deep x 11.44" high, and 23 lbs respectively.

E. Wire terminals shall be suitable for use with #10through #2 AWG size wiring.

F. SPD shall be suitable for connection to a 30A circuit breaker.

G. The SPD shall have an integral disconnecting means where required by the contract documents.

H. The full model number of the SPD shall be coordinated with the associated circuit/equipment. The SPD shall be compatible with the voltage of the circuit/equipment it is connected to. Protection shall be provided for line-neutral, line-ground, neutral-ground, and line-line.

PART 3 - EXECUTION

3.1 APPLICATION

A. The Surge Protective Device shall not have an integral disconnecting means, unless otherwise noted and except as follows:
   1. The Surge Protective Device shall incorporate an integral disconnecting means, where any of the following conditions are met:
      a. Where the surge protective device is connected to a panelboard, switchboard, switchgear, or any other equipment without any circuit breaker
      b. Where the surge protective device is connected to the line side of the service equipment.
      c. Where the drawings indicate that a disconnecting means is required.

3.2 INSTALLATION

A. Install surge protective devices in accordance with the manufacturer's recommendations, NEC requirements, UL's requirements, and the applicable codes.

3.3 FIELD QUALITY CONTROL

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

B. Test unit in accordance with manufacturer's written instructions.

3.4 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to maintain surge protective devices. Provide a minimum of 4 hours of training

END OF SECTION

SECTION 26 51 19 - LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This Section includes the following:

1. Interior and exterior lighting fixtures, lamps, and ballasts. This includes exterior luminaries mounted on exterior surfaces of buildings.
2. Emergency lighting units.
3. Exit signs.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CRI: Color-rendering index.

C. CU: Coefficient of utilization.

D. HID: High-intensity discharge.

E. LER: Luminaire efficacy rating.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast.
4. Energy-efficiency data.
5. Life, output, and energy-efficiency data for lamps.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

1. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports.

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

E. IES Photometric files for each lighting fixture. Label for the files shall match the labeling of each lighting fixture indicated in the Lighting Fixture Schedule.

F. Color samples

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

D. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

E. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

   a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

   a. Battery: Sealed, maintenance-free, unless otherwise noted on the drawings
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.4 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, unless otherwise noted.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.5 LIGHTING FIXTURES

A. See "Lighting Fixture Schedule" on the Drawings, for the manufacturer and model number of each lighting fixture.

B. Coordinate dimming control type of the lighting fixtures and the lighting controls so that they are compatible and suitable for use with each other.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Specification Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

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

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Support fixtures directly from building structure with wires, and provide support clips. For fixtures of sizes less than ceiling grid, support fixtures directly from building structure with wires, and provide metal channels spanning and secured to ceiling tees.
   1. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   2. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
   3. Install at least four independent support wires from building structure to tabs on the lighting fixture. Locate not more than 6 inches from lighting fixture corners. Wire shall have breaking strength of the weight of fixture at a safety factor of 3. Wires shall be arranged to support the fixture directly from the building structure.

C. Suspended Lighting Fixture Support:

   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   2. Aircraft Cable: Where longer than 24 inches, brace to limit swinging.
   3. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

4. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
5. Support fixtures directly from the building structure.
6. Where suspended lighting fixtures are not located directly under roof trusses, roof supports, or other structural elements, provide metal channels to span, or attach to, the roof trusses, roof supports, or other structural elements. Furnish and install metal channels such that the lighting fixtures can be suspended from the metal channels, and installed at the locations required by the contract documents.

D. Lighting Fixtures surface mounted to hard ceilings which have concealed spaces above it:

1. Provide all necessary blocking, channels, and other hardware for securing lighting fixtures to the ceiling, and the building structure as required. The blocking/channels shall be concealed above the hard ceiling. Hard ceilings shall be reinforced as required so that it can handle the weight of the lighting fixtures.

E. Wall-Mounted Lighting Fixture Support:

1. Provide all necessary blocking, channels, and other hardware for securing lighting fixtures to the wall. The blocking/channels shall be concealed inside the hollow spaces of the wall where the wall is gypsum board or other similar wall type.

F. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

G. Adjust aimable lighting fixtures to provide required light intensities.

H. Where non-IC rated lighting fixtures are installed in insulated ceilings, provide clearance between the lighting fixture and the insulation in accordance with the manufacturer's recommendations and NEC requirements.

I. Where non-fire rated lighting fixtures are recessed into fire rated ceilings, build a fire rated enclosure around the lighting fixtures such that a fire in the lighting fixture shall have to pass through the fire rated enclosure and a fire in the ceiling shall have to pass through the fire rated enclosure. The fire rating of the enclosure shall match the fire rating of the ceiling.

J. Where lighting fixtures have inputs for dimming signal (including, but not limited to, 0-10V) control wiring, but dimming signal control wiring is not provided, this shall mean that the lighting fixture is not intended to be dimmed remotely, and the lighting fixture shall be wired for full light output, unless otherwise noted.

K. Floodlights, sign lights, sports lights (including but not limited to, lighting for skating, basketball, football, etc.), or any lighting fixture that is aimable, shall be aimed in order to maximize the average lighting level across the entire area being lit, and to minimize the average-to-minimum lighting level across the entire area being lit, prior to final acceptance of the project. The contractor shall include in his bid price, a return trip to the site up to 6 months after final acceptance of the project, in order to re-aim any or all of the lighting fixtures. Coordinate with the owner and obtain approval, before aiming or re-aiming lighting fixtures.

L. Lighting fixtures with field adjustable light output shall be adjusted in order to maximize the average lighting level across the entire area being lit, and to minimize the average-to-minimum lighting level across the entire area being lit, prior to final acceptance of the project. The contactor shall include in his bid price, a return trip to the site up to 6 months after final acceptance of the project, in order to re-adjust the lighting levels. Coordinate with the owner and obtain approval, before adjusting or re-adjusting lighting levels.

M. Time controls shall be programmed in accordance with the direction provided by the owner, prior to final acceptance of the project. The contractor shall include in his bid price, a return trip to the site up to 6 months after final acceptance of the project, in order to re-program the time controls. Coordinate with he owner and obtain approval, before programming or re-programming the time clocks.

N. Where lighting fixtures with similar physical appearance are located in the same area, orient the lighting fixtures in the same manner, unless otherwise noted. For example, where there are 10 center basket troffer light fixtures in a row, the basket of all the lighting fixtures shall be oriented in the same manner for neat and aesthetic appearance, unless otherwise noted.

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.3 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the lighting fixtures.

B. The System Supplier shall schedule and present a minimum of 4 hours of documented formalized instruction for the building owner, detailing the proper operation and maintenance of the installed lighting fixtures.

C. The instruction shall be presented in an organized and professional manner by a person factory trained in the operation and maintenance of the equipment and who is also thoroughly familiar with the installation.

END OF SECTION

SECTION 27 15 13 – TELECOMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUBMITTALS

A. Product Data: Include data on features, ratings, and performance for each component specified.

B. Shop Drawings. A complete set of shop drawings shall be supplied. The shop drawings shall be reviewed and stamped by a RCDD certified person. This package shall include but not be limited to:
   1. Control panel wiring and interconnection schematics. Contractor is responsible for verifying that all the voltages, inputs and outputs are compatible with each other.
   2. Complete point to point wiring diagrams.
   3. Riser diagrams.
   4. Complete floor plan drawing locating all devices and equipment in 1/8" = 1'-0" scale plan. Show the placement of each individual device/equipment as well as raceway size/ routing, junction box size/location, and wire/cable size/type/quantity/color/routing. This includes, but is not limited to, the following:
      a. Cable tray layout
      b. Location of rack in the electrical/telecom room, showing clearances from walls and equipment.
   5. Show elevation drawing of all equipment. This includes, but is not limited to, the following:
      a. Equipment rack elevation.
   6. Detailed system operational description.
   7. Complete system bill of material.

C. Operation and Maintenance Data

D. Field quality control test reports

E. Equipment and cable identification/labelling schedule

F. Qualifications of persons and companies working on the project.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer shall have personnel certified by BICSI on staff
   1. Layout Responsibility: Preparation of Shop drawings by a person certified by BICSI as an RCDD

2. Installation Supervision: Installation shall be made under the direct supervision of a person certified by BICSI as an RCDD

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff
1. Testing Agency's Field Supervisor: A person certified by BICSI as an RCDD

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

D. Comply with NFPA 70.

E. Comply with NECA 1.

1.4 COORDINATION

A. Coordinate the equipment indicated in this specification section with all other equipment and systems it connects to. All input/output/communications interfaces/modules shall be compatible and suitable for use with each other.

B. Coordinate programming of system with the preferences of the owner. Comply with the owner's requirements, except where it conflicts with the applicable codes or the requirements of the authorities having jurisdiction.

C. Where equipment are connected to the data network system, coordinate all network settings/configurations with the owner's IT (Information Technology) department.

D. Coordinate line voltage power requirements prior to starting any work to ensure that power is provided to all equipment. The contractor shall provide line voltage power to all equipment that require it, in accordance with the manufacturer's recommendations and NEC requirements.

1.5 DEFINITIONS

A. BICSI: Building Industry Consulting Services International

B. RCDD: Register Communications Distribution Designer (Certified by BICSI)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Where the contract documents specifies a product name, model, or manufacturer, this product shall be considered as the basis-of-design product. The contractor shall provide the basis-of-design product or approved equal. All products shall be submitted for review and approval by the design team.

2.2 DATA EQUIPMENT RACK

A. Provide Middle Atlantic Products, Inc. WRK Series floor standing enclosure, with the following features:

1. EIA compliant 19" gangable equipment rack.
2. Overall dimensions of the rack shall be 83.13" high x 24.25" wide x 27.63" deep.
3. Usable height shall be 77" (44 rackspaces), usable depth shall be 25.75".
4. Fully welded construction shall provide a UL Listed 2,500 lb weight capacity.
5. Rack shall be constructed of the following materials: top and bottom shall be 14-gauge steel, horizontal braces shall be 16-gague steel welded to integral structural side panels of 16-gague steel giving an 1/8" thick structure, and all structural elements shall be finished in a durable black powder coat. Rack shall include locking and latching rear door. Rack shall come equipped with two pairs of 11-gague steel rackrail with tapped 10-32 mounting holes in universal EIA spacing. Finished in black e-coat with numbered rackspaces. Top and bottom of rack shall have a vertical slotted vent pattern. Rack shall have removable split rear knockout panels with ½", ¾", 1", and 1-1./2" electrical knockouts installed in base, and removable split rear knockout panels with ½", ¾", 1", and 1-1/2" electrical knockouts, and BNC knockouts for UHF/VHF antennae installed in top. Grounding and bonding stud shall be 14-20 threaded, installed in base of enclosure.
6. Rack shall be UL listed in the US.
7. Rack shall be warranted to be free of defects in material or workmanship under normal use and conditions for the lifetime of the rack.
8. Provide the following items:
   a. Provide Middle Atlantic UQFP-4D fan with the following features:
      1) Includes display
      2) 100 CFM air flor
      3) 1.1A @5VDC power consumption
      4) Includes UL Listd 5VDC power supply with 6' cord and temperature probe with a 9' cord.
      5) Overtemp alarm output shall be a normally open dry contact closure.
      6) 3.49" or 2 rackunits high
      7) Fans shall be located at the top of the rack, unless otherwise noted

2.3 CABLE TRAY

A. Provide B-Line 258 Series ladder type cable tray with the following features, unless otherwise noted:
1. Ladder type trays shall consist of two longitudinal members (side rails) with transverse members (rungs) welded to the side rails. Rungs shall have a minimum cable bearing surface of 7/8" with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side raisl. Each run shall be capable of supporting the cable load, with a safety factor of 1.5, and a 200 lb conscentrated load when tested in accordance with NEMA VE 1, section 5.4.
2. 4" NEMA VE Loading Depth and 5" Side Rail Height
3. Pre-Galvanized Steel construction. Straight sections, fitting side rails, and rungs shall be made from structural quality steel meeting the minimum mechanical properties and mill galvanized in accordance with ASTM A653 SS, Grade 33, coating designation G90.
4. 6" rung spacing
5. 12" minimum cable tray width (increase width as required to accommodate the size/quantity of the associated cables; or if the drawings indicate a greater width)
6. Length as required
7. Splice plates shall be bolted type . The resistance of fixed splice connections between an adjacent section of tray shall not exceed 0.00033 ohm. Splice plate construction shall be such that a splice may be located anywhere within a continuously supported spa without diminishing rated loading capacity of the cable tray. Splice plates shall have the following construction:
   a. Pre-Galvanized Steel Construction. Splice plates shall be manufactured of high strength steel, meeting the minimum mechanical properties of ASTM A1011 HSLAS, Grade 50, Class 1. Each splice plate shall be attached with ribbed neck

carriage bolts and serrated flange locknuts. Hardware shall be zinc plated in accordance with ASTM B633 SC1 for pre-galvanized cable trays.

8. UL Listed

B. Cable Tray shall comply with NEMA Standars Publication Number VE 1, "Cable Tray Systems"

2.4 CATEGORY 6 CABLE

A. Aboveground cables, which are located indoors (this applies where no part of the cable is located outdoors or underground): The entire end-to-end run of the Category 6 Cable shall have the following features:
1. ANSI/TIA Category: 6
2. Cable Type: Unshielded
3. Jacket Color: BLUE for data cables, and WHITE for telephone cables
4. Cable shall be Plenum Rated (CMP Type)
5. Remote Powering:
   a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
   b. Power available at PD (Powered Device): 71.3 watts minimum
   c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
6. UL Listed

B. Outdoor or Underground cables (this applies where the cable is fully or partially located outdoors or underground): The entire end-to-end run of the Category 6 Cable shall have the following features:
1. ANSI/TIA Category: 6
2. Cable Type: Unshielded
3. Jacket Color: BLUE for data cables, and WHITE for telephone cables
4. Cable shall be Plenum Rated (CMP Type)
5. Remote Powering:
   a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
   b. Power available at PD (Powered Device): 71.3 watts minimum
   c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
6. UL Listed
7. Cable shall be suitable for indoor and outdoor conditions. Cable shall be sunlight resistant. The manufacturer shall state that the cable can be installed in below-grade conduit, duct, and wet environments.

2.5 CATEGORY 6 PATCH PANELS

A. Provide Category 6 Patch Panels with the following features:
1. ANSI/TIA Category: 6
2. Cable Type: Unshielded
3. Panel Style: Straight
4. Rack Type: EIA 19 INCHES
5. Rack Units: 1
6. Total Ports, quantity: 24
7. Remote Powering:
   a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
   b. Power available at PD (Powered Device): 71.3 watts minimum
   c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
8. UL Listed

2.6 TELEHPONE AND/OR DATA OUTLETS

A. Provide Category 6 jacks in each telephone and/or data outlet.

B. Category 6 jacks shall comply with the following:
   1. NASI/TIA Category: 6
   2. Remote Powering:
      a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
      b. Power available at PD (Powered Device): 71.3 watts minimum
      c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
   3. UL Listed

C. Wall plates shall comply with the following:
   1. Non-metallic
   2. UL Listed

2.7 UNINTERRUPTIBLE POWER SUPPLY

A. Provide Eaton 5PX3000RT3UNG2 UPS with the following features:
   1. Dimensions: 19" deep x 5.1" high x 17.2" wide; 3 rack units high
   2. Weight: 72.8 lbs
   3. UL Listed
   4. Electrical Output:
      a. Battery type: Sealed, lead-acid
      b. Receptacle: (1) L5-30R, (6) 5-20R
      c. Wattage: 3000W
      d. Topology: Line-interactive
      e. VA Rating: 3000 VA
   5. Electrical Input:
      a. Input Connection: L5-30P
      b. Input Nominal Voltage: 120V
      c. Nominal Frequency: 50/60Hz
      d. Input power factor: 1
      e. Input cord length: 10 ft
   6. Communications
      a. User interface: LCD graphical display
      b. Gigabit Network Card (NETWORK-M2) is included
      c. Software compatibility: Brightlayer Data Centers suite
   7. Efficiency: 98%
   8. Maximum heat dissipation: 208 BTU online; 1136 BTU battery

2.8 RACK MOUNTED SURGE PROTECTOR

A. Provide CyberPower CPS1220RMS with the following features:
   1. Input:
      a. Voltage: 120VAC
      b. Maximum Input Current: 20A
      c. Switch: Lighted On/Off
      d. Plug Type: NEMA 5-20P
      e. Cord length: 15 feet
   2. Output:
      a. Voltage: 120VAC

b. Overload protection: 20A
c. Number of Outputs: 12 (2 in the front, 10 in the rear)
d. Output type: NEMA 5-20R
e. LED indicators: Power, Surge, Ground

3. Surge Protection and Filtering
   a. Surge Suppression: 1,800 Joules
   b. Maximum Surge Current: 90,000 Amps
   c. Maximum Surge Voltage: 6,000 volts
   d. Clamping Voltage: 400V(N-H, N-G), 500V (L-G)
   e. Response Time: 1 nanosecond
   f. EMI/RFI Filtration: Yes
   g. Attenuation: Up to 50dB
4. Physical:
   a. Form Factors Supported: 1U Rackmount
   b. Style: Rackmount, Vertical Rackmount, Under-Counter
   c. Enclosure Construction: Metal
   d. Adjustable mounting brackets: 1 set
   e. Dimensions: 17.5" wide x 1.75" high x 1.5" deep
   f. Weight: 6.43 lbs
5. Certifications:
   a. UL1363 and UL1449 certified by ETL

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Provide junction boxes as required, in accordance with the NEC and the manufacturer's recommendations.

B. Wiring methods for low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring:
   1. In the succeeding paragraphs, "raceway" shall mean conduit; and, minimum conduit size shall be ¾", unless otherwise noted and except as follows:
      a. Where surface raceway is required elsewhere in the contract documents, "raceway" shall mean surface raceway.
   2. Wiring that is exposed, concealed inside walls/floor, or concealed above inaccessible ceilings:
      a. All wiring shall be installed in raceway.
   3. Wiring that is concealed above accessible ceilings:
      a. All wiring shall be installed in raceway, unless otherwise noted and except as follows:
         1) Raceway may be omitted where all of the following conditions are met:
            a) Wiring is used for Communications Circuits or Class 2 Circuits.
            b) Wiring is used in dry locations.
            c) Wiring is used in aboveground applications.
            d) Wiring is not subject to physical damage.
            e) Wiring is supported and secured at intervals which do not exceed 3 feet.
            f) Wiring is supported by hangers and supports from the building structure.
            g) Wiring is not laid on ceiling tiles.
            h) Wiring is not fastened in a manner that puts tension on the wiring.
            i) Wiring is plenum rated (UL Type CMP).

j) Wiring is supported by UL Listed Metal J-Hooks (with rounded edges and integral cable retainer metal clip) and secured together with plenum rated nylon straps or clamps (the use of stapes is prohibited).
k) Wiring is concealed above accessible suspended ceilings (this includes, but is not limited to, ceiling spaces above grid type ceilings with removable ceiling tiles).
l) Raceway is not required by the NEC.

C. All junction box covers shall be painted ORANGE, and labeled "DATA"

D. Coordinate electrical power supply connection type with the equipment. Where the equipment requires a receptacle connection, provide a receptacle. Where the equipment requires a hardwired connection, provide a hardwired connection. Coordinate all work with the manufacturer and the installation manuals. All work shall comply with the NEC, the manufacturer's recommendations, and the contract documents.

E. The total load (in volt-amperes) of the devices and equipment powered from the UPS (Uninterruptible Power Supply) shall not exceed the rating (in volt-amperes) of the UPS.

F. Coordinate weight of rack mounted equipment with the load rating of the rack. Make sure that the load rating of the rack is not exceeded.

G. Where racks or cabinets are wall mounted, provide metal channels or fire retardant plywood boards that are capable of supporting the equipment mounted on it, to span and attach to the wall studs, wall columns, or other wall elements. Where the wall elements cannot support the racks or cabinets, provide independent freestanding supports for the racks or cabinets. The metal channels, boards, and supports shall be painted to match adjacent wall surfaces where installed in finished spaces (including, but not limited to, offices, conference rooms, etc.)

H. Provide hangers and supports (including, but not limited to, mounting plates, hanger rods, etc.) as required to suspend ceiling mounted equipment from the building structure.

I. Where low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio wiring, enter or pass through boxes, enclosures, and furniture/fixtures/equipment, provide grommets and bushings in accordance with the manufacturer's recommendations and NEC requirements.

J. Each UPS shall be powered from a dedicated 120VAC, 30A branch circuit through a NEMA L5-30R, 120VAC, 30A receptacle. Where the drawings do not show these branch circuits or receptacles, provide 120VAC, 30A circuit breakers (short circuit current rating of the breaker shall not be less than the short circuit current rating of the associated panelboard) at the nearest panelboard, for each UPS, unless otherwise noted. Provide branch circuit wiring/conduit and the receptacle for each UPS, in accordance with NEC requirements, and make all UPS fully operational.

K. Provide UPS software at one of the computers of the owner, to allow the owner to monitor the UPS remotely.

L. Cable Trays:
1. Install cable trays in accordance with the manufacturer's recommendations and NEMA VE 2 (Cable Tray Installation Guidelines).
2. Where data equipment racks are located inside electrical/telecom rooms, provide cable trays from the rack up to the adjacent corridor, aisle, or hallway, unless otherwise noted. The telecom cables associated with the rack shall run from the corridor, aisle, or hallway, up to the rack, supported from the cable tray. Provide the cable tray regardless of

whether or not it is indicated in the drawings. Provide multiple parallel cable trays as required to accommodate all the cables that are supported from it.

3. Make changes in direction and elevation using the cable tray manufacturer's recommended fittings.
4. Make cable tray connections using manufacturer's recommended fittings.
5. Provide hangers and supports for the cable tray up to the building structure, in accordance with the manufacturer's recommendations and NEC requirements.
6. Remove burrs and sharp edges from the cabler trays.
7. Provide #4 ground wire in ¾" conduit minimum (to ground/bond all sections of the cable tray) up to the building grounding electrode system, unless otherwise noted. Provide bonding jumpers, grounding clamps, and ground wire clamps as required.

M. Equipment Rack
1. Secure the rack to the floor with bolts in accordance with the manufacturer's recommendations.
2. Provide #4 insulated ground wire in ¾" conduit minimum (to ground/bond the rack) up to the building grounding electrode system, unless otherwise noted, and except as follows: where there is a telecommunications ground bar in the same room as the rack, connect the ground wire to the ground bar. Provide bonding clamps, and ground wire clamps as required.
3. Coordinate exact location of rack mounted equipment with the associated branch circuit receptacles, input/output cords/cables, and other associated items. Cord/cables shall have sufficient length to reach their associated equipment. Make sure that all equipment at the rack are fully operational.

N. Where the drawings do not show a telecommunications ground bar in the same room as the equipment rack, provide the following unless otherwise noted:
1. Provide Harger GBI14424C telecommunication ground bar with the following features:
   a. UL Listed
   b. 24" long x 4" high x ¼" thick copper ground bar with mounting brackets, standoff insulators, and connectors for conductors
2. Provide one of the following from the telecommunications ground bar to the building electrical service ground bar (or service equipment ground bus if there is no electrical service ground bar):
   a. Provide 500KCMIL insulated ground wire in 1-¼"C, where the overall length of the wire is less than 200 feet.

O. Where Category 6 cables, outlets, and patch panels are required by other systems (including, but not limited to, CCTV, Public Address, Intercom, Access Control, Intrusion Detection, Electric Submetering, and Lighting Control Systems), the cables, outlets, and patch panels shall comply with the requirements indicated in this specification section.

3.2 INSTALLATION

A. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

B. Cables shall have a minimum separation of 12 inches from 120V or higher power wiring. Cables shall have a minimum separation of 12 inches from light fixtures.

C. All wall and floor penetrations shall be sleeved. All conduit and sleeve ends must have bushings to prevent chafing. Where a conduit or other through-penetration device is installed through a fire rated assembly, the opening around the sleeve and the hole through the sleeve shall be sealed with an Underwriters Laboratory approved fire rated sealant material after the cables have been installed.

D. Install cables without damaging conductors or jacket.

E. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

F. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
   1. Pull cables simultaneously if more than one is being installed in same raceway.
   2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
   4. Monitor cable pulling tensions.

G. Install cables parallel and perpendicular to surfaces or structural members and follow surface contours where possible.

H. Wiring within Wiring Closets and Enclosures: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

I. Separation of Wires: Comply with TIA/EIA-569-A rules for separating unshielded copper telephone and data communication cabling from potential EMI sources, including electrical power lines and equipment.

J. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect panels.

K. Use splice and tap connectors compatible with media types.

L. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

M. In the communications equipment room, install a 5-foot- long service loop on each end of cable.

N. Cable support inside wiring closets, telecommunications closets, data closets:
   1. Support horizontal and backbone cabling from the fire retardant plywood board in each closet.
   2. Provide cable ties and cable tie mounts to support the horizontal and backbone cabling from the plywood board. Provide cable ties every 3".
   3. Cable tie mount shall be manufactured by Panduit or approved equal and shall use galvanized steel screws as the mounting method. Cable tie mount shall be UL Recognized. Cable tie mount size shall be suitable for the cables being supported.

O. Install all devices and equipment in accordance with the manufacturer's requirements.

P. Prior to installing devices and equipment, the contractor shall coordinate the exact locations where the devices and equipment are being installed with the plan drawings and existing conditions, and shall notify the engineer immediately if there are any issues or conflicts. The coordinated locations shall be indicated in the shop drawing submittals. Where conflicts are found during or after the shop drawing submittal process, but before installation of the devices and equipment, the contractor shall notify the engineer of the conflict, and shall adjust the locations of the devices and equipment, where directed by the engineer to do so. The

contractor's bid price shall include adjusting the locations of devices and equipment up to 12 feet from the locations on the plan drawings, unless otherwise noted.

Q. All equipment shall be installed plumb and level.

R. Clean all equipment in accordance with the manufacturer's recommendations.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Provide the following tests and inspections for all cables:
      a. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
      b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   2. Provide the following tests and inspections for Category 6 cables, using test equipment that have been calibrated within the last 12 months prior to the testing (provide proof of calibration)
      a. Wire Map
      b. Length
      c. Propagation Delay
      d. Delay Skew
      e. DC Loop Resistance – recorded for information only
      f. DC Resistance Unbalance – recorded for information only
      g. Insertion Loss
      h. NEXT (Near-End Crosstalk)
      i. PS NEXT (Power Sum Near-End Crosstalk)
      j. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
      k. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
      l. ACR-F (Attenuation to Crosstalk Ratio Far-End)
      m. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
      n. Return Loss
      o. TCL (Transverse Conversion Loss) – recorded for information only
      p. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

B. Retesting: Correct deficiencies and retest. Prepare a written record of tests.

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

3.4 IDENTIFICATION

A. Each equipment shall be labeled with an address/identification name/number which matches information provided in the submittals or indicated in the drawings. Identify each cable segment between equipment with a unique number corresponding to the address/identification name/number of the associated equipment. Provide a cable schedule which identifies each cable segment and the associated equipment.

3.5 SOFTWARE SERVICE AGREEMENT

A. Provide software technical support as follows:
   1. Beginning at Substantial Completion, service agreement shall include software support for two (2) years.
   2. Technical support shall include the following:
      a. Toll free technical support via phone
      b. Technical support via the internet

B. Provide software upgrade service as follows:
   1. At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   2. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.6 DOCUMENTATION AND TRAINING

A. The contractor shall provide to the owner, complete manuals of the completed system. The manuals shall include operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams, and a manufacturer's suggested spare parts list.

B. In addition to the above manuals, the contractor shall provide the services of the manufacturer's trained representative for a period of eight (8) hours to instruct the owners' designated personnel on the operation and maintenance of the entire system.

C. Training shall be on-site, and hands-on, using the actual equipment installed at the project site.

D. Provide training on how to operate and maintain the system. Also, provide the following additional training:
   1. How to monitor UPS status remotely through the network.

END OF SECTION

SECTION 27 53 19 - EMERGENCY RESPONDER RADIO SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. This specification section includes requirements for the emergency responder radio system.

B. All work in the contract documents shall be considered as base bid, except where the work is noted as an "alternate" or an "add alternate". Where work is not noted as an "alternate" or an "add alternate", it shall be considered as base bid. The list or narrative which indicates which items (if any) shall be considered as "alternates" or "add alternates", is not included in this specification section, but is included elsewhere in the contract documents. Where the contract documents do not indicate that the emergency responder radio system is an "alternate" or an "add alternate", the system (including, but not limited to, all work indicated in this specification section) shall be considered as base bid. Where the contract documents indicate that the emergency responder radio system is an "alternate" or an "add alternate", this shall mean the following:

1. PRELIMINARY TESTING: The base bid shall include radio signal testing prior to installation of the emergency responder radio system, and submitting the test results to the owner and permit department for review.
2. AHJ COORDINATION: The base bid shall include coordinating with the permit department, and finding out whether or not the permit department will require that an emergency responder radio system be installed. The base bid shall include providing a report to the owner stating whether or not the permit department will require that an emergency responder radio system be installed.
3. SYSTEM INSTALLATION: The alternate or add alternate shall include all work required for a complete and fully operational emergency responder radio system, including but not limited to, all work indicated in this specification section (except for the PRELIMINARY TESTING and AHJ COORDINATION work which are included in the base bid).

1.3 GENERAL REQUIREMENTS

A. All work shall be performed in accordance with the latest edition of the Federal/State/Local Codes, Americans with Disabilities Act, International Building Code, NFPA Codes, NEC and the requirements of the Authorities Having Jurisdiction.

B. Furnish and install all required wiring, conduit, junction boxes, pull boxes, surface/recessed device boxes, fittings, conduit bodies, supports, access doors, hardware, accessories, etc. required for a complete and working system.

C. Contractor shall perform site visits and shall thoroughly familiarize himself with the drawings and field conditions, before submitting a bid or before submitting a price proposal. Field verify all important dimensions.

D. The contractor shall coordinate his work with all other contractors and all other trades before installation of his work in chases, ceiling spaces and other areas where conflict may occur.

E. The contractor shall coordinate his work with all contract documents, shop drawings, and equipment drawings.

F. The contractor shall obtain and pay for all permits, and shall pay all fees relative to the installation of his work. The contractor shall apply and obtain permits from the Permits Department.

G. The contractor shall core drill holes in existing concrete walls, ceilings, and floors as required for the installation of wiring and conduit. The contractor shall use ground penetrating radar to scan the concrete for any obstructions and/or structural elements/components prior to core drilling. Core drilling shall be made only at locations which are free of obstructions and/or structural elements/components. Do not drill, cut, or damage beams, joists, trusses, and other load bearing structures. All work shall be reviewed and approved by the owner, the architect, the structural engineer, and the AHJ.

H. Where junction boxes or electrical equipment are required to be installed above non-accessible ceilings or concealed inside walls, the contractor shall furnish and install access doors to make the junction boxes or electrical equipment accessible.

I. All electrical equipment shall be Underwriter's Laboratory (UL) Listed and Labeled.

J. Exact location of all equipment and accessories shall be verified in the field and coordinated with all other trades. Adjust locations to suit field conditions. Comply with clearances as required by the NEC, the manufacturer, and applicable codes.

K. The contractor shall extend wiring and conduit to all equipment requiring electrical connections. Before "rough-in" of outlets, the location and type of connections/outlet shall be verified from shop drawings of the equipment.

L. Comply with all safety regulations, including but not limited to OSHA, MOSHA, and all Electrical Safety Regulations.

M. Unless otherwise noted as "existing", "by others", or "NIC", all work and equipment are new and shall be furnished and installed by the contractor.

N. Where the word "provide" is used, this shall mean "furnish and install".

O. Provide dedicated neutral wires for all branch circuits.

P. Cables and raceway shall run parallel or perpendicular to wall and ceiling structures (columns, joists, support beams, etc.) for a neat appearance.

Q. Provide firestopping around penetrations of ceilings/floors and fire rated walls. Maintain the fire resistance rating of the ceilings, floors and walls. Install UL listed fire stopping material in accordance with the manufacturer's recommendations, and UL's requirements.

R. Provide grounding and bonding of all metallic antenna, raceway, junction boxes, enclosures, trough, wireway, internal dividers (for junction boxes, enclosures, etc), and equipment in accordance with the manufacturer's recommendations and NEC requirements.

S. Furnish and install all equipment in accordance with the requirements of the NEC, the manufacturer, UL, applicable codes, and the contract documents.

T. Connectors and terminations for conductors shall be compatible with the conductor size and material, and shall be UL listed and NEC compliant.

U. Sufficient access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment. Coordinate exact location of electrical equipment with other trades and field conditions to ensure that access and working space is provided in accordance with the NEC and the manufacturer's recommendations.

V. Provide junction boxes as required by the NEC, the equipment manufacturer, or field conditions. Do not exceed the maximum pulling tensions of the wire or cable. The junction boxes shall be sized per NEC, and shall be suitable for the environment where it is being installed in accordance with the NEC and the manufacturer's recommendations.

W. All labor, materials, tools, equipment and services required for a complete and fully operational system shall be supplied whether or not listed herein.

X. All software shall be the latest version at the time of installation.

Y. All equipment shall be suitable for its intended use, environment, and location in accordance with the NEC, UL, the manufacturer's recommendations, and the contract documents.

Z. All work shall be coordinated with all other trades.

AA. Hangers and supports shall comply with all of the following performance requirements:
1. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

BB. Suspended or ceiling mounted electrical equipment shall be supported from the building structure. Where suspended electrical equipment are not located directly under roof trusses, roof supports, or other structural elements, or where other equipment (mechanical, plumbing, etc) are located above the electrical equipment, provide metal channels and other supports to span, or attach to, the roof trusses, roof supports, or other structural elements. Metal channels and other supports shall be provided as required in order to support the electrical equipment.

CC. The contractor shall provide all labor, software, licenses, programming, materials, equipment, hardware, mounting, wiring, conduit, junction boxes, power supplies, batteries, equipment enclosures, and accessories as required for a complete and fully operational system. The contractor shall provide all startup and testing as required, in order to confirm that the system operates in accordance with the contract documents. The system shall comply with all applicable codes, the manufacturer's recommendations, and the requirements of the AHJ.

DD. All raceway with emergency responder radio system wiring shall be dedicated for the emergency responder radio system wiring only. Do not install other wiring in the raceway.

EE. Contractor shall be entirely responsible for temporary power. All applications, fees, temporary connections, etc. shall be made by the contractor.

1.4 DEFINITIONS

A. A: Ampere
B. AIC: Ampere Interrupting Capacity
C. AHJ: Authority Having Jurisdiction

D. AWG: American Wire Gauge
E. BDA: Bi-Directional Amplifier
F. C: Conduit
G. Coax: Coaxial
H. DAO: Delivered Audio Quality
I. DAS: Distributed Antenna System
J. EMT: Electrical Metallic Tubing
K. EPA: Effective Projected Area
L. FCC: Federal Communications Commission
M. G: Ground
N. IFC: International Fire Code
O. KA: Thousand Amperes
P. KAIC: Thousand Ampere Interrupting Capacity
Q. UL: Underwriter's Laboratories Inc.
R. NEC: National Electrical Code
S. NFPA: National Fire Protection Association
T. MC: Metal Clad
U. MTD: Mounted
V. RMC: Rigid Metal Conduit
W. RSSI: Received Signal Strength Indicator
X. SCCR: Short Circuit Current Rating
Y. SPD: Surge Protective Device
Z. U.O.N.: Unless Otherwise Noted
AA. UPS: Uninterruptible Power Supply
BB. UL: Underwriter's Laboratories Inc.
CC. V: Volts
DD. VAC: Volts Alternating Current
EE. VDC: Volts Direct Current
FF. W: Watts
GG. Where "DAS" or "emergency responder radio enhancement system" is indicated in the contract documents, this shall mean "Emergency Responder Radio System".

1.5 SUBMITTALS

A. Product Data: For each type of product indicated, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project. The drawings shall be sealed/signed by a Fire Protection Engineer licensed in the State where the project is located. For example, if the project is located in Maryland, the drawings shall be sealed/signed by a Fire Protection Engineer licensed in the State of Maryland.

1. Riser Diagram:

a. Show single-line interconnections between all devices and equipment for power and control wiring/cables. Show wire/cable types and sizes.

b. Show wire/cable size/type/manufacturer/model#. Show where 2-hour fire rated wiring is used, and show where the 2-hour fire rated wiring changes to non-fire rated wiring.

c. Indicate required power and control wiring connections for each device and equipment.

d. The floor where each device and equipment is located shall be indicated in the Riser Diagram. The label for each device and equipment shall be indicated in the Riser Diagram.

2. Dimensioned plan and elevations of control panels, displays, and annunciators. Show access and workspace requirements.

3. Include complete floor plans to indicate equipment and device locations. The label of each device and equipment shall be indicated on the floor plans. The labels in the floor plan shall match the labels in the Riser Diagram. Show type, size and route of wiring and conduits. Floor plans shall be drawn in 1/8" = 1'-0" scale. The locations where conduit and surface metal raceway are used shall be clearly shown on the floor plans. Show where 2-hour fire rated wiring is used, and show where the 2-hour fire rated wiring changes to non-fire rated wiring.

4. Wiring Diagrams: Power, signal, and control wiring, and grounding. All wires required for a complete and fully operational system shall be included in the wiring diagrams.

5. Control panel, display, and annunciator elevation (Front, Side, and Interior). Elevation shall be dimensioned.

C. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, and location.

D. Battery sizing calculations.

E. Signal gain and loss calculations.

F. Field quality-control test reports.

G. Qualifications of the Contractor.

H. Qualifications of the Radio Signal Testing Company.

I. As-built drawings. Provide as-built conditions for the wiring diagrams, riser diagrams, and plan drawings. The drawing shall include the labels/tags on the cables.

J. Video of demonstration and training.

K. Warranties.

L. Contractor's Certificate.
1. The Contractor shall submit a signed and dated letter to the owner and the engineer certifying the following:
   a. He shall certify that all work has been performed in accordance with the contract documents (including, but not limited to: any amendments, addendums, and contract modifications);
   b. He shall certify that all work has been inspected and approved by the Authorities Having Jurisdiction; AND,
   c. He shall certify that all work has been performed in accordance with the IFC codes, NFPA codes, and all applicable codes.

M. Operations and Maintenance Manuals: The operations and maintenance manuals shall include information on how to operate and maintain devices and equipment, during normal

and emergency conditions. Also, include the following in the operations and maintenance manuals:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

2. Field quality control test results

N. Resume of contractor with the following information:

1. Resume showing compliance with the QUALITY ASSURANCE paragraph

O. Sequence of Operations:
1. Provide a sequence of operations matrix describing how the equipment will operate in normal and emergency conditions.

P. Permit Submission
1. The contractor shall submit Product Data, Riser Diagrams, Plan Drawings, Sequence of Operations, and other information required/requested by the permit department, to the permit department, before starting any work. All designer/installer/professional qualifications/certifications/seals/signatures that are required by the permit department shall be provided by the contractor. Resubmit as required to make clarifications or revisions to obtain approval.

Q. Mounting equipment and attachments for the antenna shall be submitted to the structural engineer for review/approval.

R. Provide a certificate or letter indicating that the emergency responder radio system has been approved by the AHJ.

1.6 QUALITY ASSURANCE

A. Contractor Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than 2 hours' normal travel time from contractor's place of business to Project site.

2. Provide the services of a contractor that is experienced in the design and installation of these types of systems. The contractor shall provide resume and references that they have provided at least 2 types of similar systems in the past 5 years.

3. The contractor shall make sure that the system complies with the following:

a. All individual components of the system are interoperable and are compatible with each other.

b. Each individual component of the system as well as the entire system is in compliance with the contract documents.

c. All labor, materials, programming and accessories are provided for a complete and fully operational system.

4. The contractor shall coordinate communications/data/alarm/coax cabling, power/control wiring, amplifiers, antennas, connectors, couplers, splitters, power supplies, surge

protection, and all other devices/equipment in the entire system, to ensure that all the devices/equipment are compatible with each other. Coordinate with all the different manufacturers and make sure the minimum specifications for any piece of equipment meets the requirements of all the other pieces of equipment to ensure that the system is complete and fully operational in accordance with the recommendations of all the equipment manufacturers.

5. Within the warranty period, the contractor shall be capable of being on site within 24 hours of a request for service. This shall include nights, weekends, and holidays.

B. Radio Signal Testing Company Qualifications:
   1. The personnel who will perform the testing shall comply with the applicable codes. A copy of the radio operator's license, certifications, and experience shall be submitted for review and approval.
   2. The testing company must show experience in the design and testing of distributed antenna systems used by the emergency responders who will respond to the emergencies associated with the building. Sample radio signal test reports shall be provided.

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

D. All work shall comply with the National Electrical Code, International Building Code, NFPA codes, and the requirements of the Authority Having Jurisdiction.

1.7 COORDINATION

A. Coordinate all work with all other trades.

B. Provide equipment, devices, hardware, accessories, wiring, conduit, and circuits as required to make the system complete and fully operational.

C. Coordinate all work with the Fire Alarm Contractor. Hire and pay the Fire Alarm Contractor for all work related to the fire alarm system, including but not limited to, the following:
   1. Furnish and install fire alarm monitor modules and the associated wiring/conduit, programming, and all other devices/equipment, as required for monitoring the emergency responder radio system. Make sure that signals from the radio system are monitored by the fire alarm system.
   2. The signals that shall be monitored by the Fire Alarm System shall include, but not be limited to, the following (see the applicable codes for a complete list of signals that shall be monitored):
      a. Emergency Responder Radio System, loss of normal AC power supply
      b. Emergency Responder Radio System, battery charger failure
      c. Emergency Responder Radio System, malfunction of the donor antenna
      d. Emergency Responder Radio System, failure of active RF-emitting device
      e. Emergency Responder Radio System, low-battery capacity at 70-percent reduction of operating capacity
      f. Emergency Responder Radio System, failure of critical system components
      g. The communications link between the fire alarm system and the emergency responder radio enhancement system.

1.8 WARRANTY

A. The Contractor shall guarantee that all work performed and all materials and equipment installed by him are free from defects. He shall repair or replace any defective equipment, materials or workmanship, free of cost to the Owner for a period of TWO (2) YEARS from date of acceptance of the system.

B. During this warranty period the Contractor shall:
   1. Correct and make good all defects. Faulty equipment and materials shall be repaired or replaced as required to produce satisfactory results as directed by the engineer and without additional cost to the Owner. Contractor shall provide service within 24 hours after the call has been made by the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following (the contractor shall select manufacturers and products which are compatible with each other; and, comply with the applicable codes, this specification section, and the requirements of the AHJ):
   1. Honeywell (Bi-Directional Amplifier Panel, Digital Signal Booster Panel, Battery Backup Panel, External Annunciator Panel, Directional Coupler, Splitter)
   2. Citel (Coax Surge Protector)
   3. Ditek (120VAC Surge Protective Device)
   4. Radio Frequency Systems Inc (coaxial cables)
   5. Comba (Antenna)

2.2 GENERAL

A. An emergency responder radio system shall be provided, so that there is adequate radio signal strength into the building and out of the building. The emergency responder radio system shall comply with all of the following:
   1. All equipment shall comply with the applicable codes and the requirements of the AHJ. All equipment shall be submitted for review/approval to the permit department. All equipment shall be inspected/approved by the AHJ.
   2. All equipment shall be UL Listed and suitable for its intended use and location. Do not install equipment in areas which are incompatible with its environmental ratings.
   3. All equipment shall be located in areas which are acceptable to the AHJ, and comply with the requirements indicated in the applicable codes.
   4. All equipment required for a complete and fully operational system shall be provided, whether or not it is indicated in this specification section.
   5. Provide hangers, supports, and mounting equipment for all equipment.
   6. The emergency responder radio system shall comply with the requirements indicated in IFC 510, NFPA 1221 9.6, and NFPA 1225. The latest edition of these codes which are adopted by the AHJ shall apply. Where there is a conflict in the codes, the more stringent requirement shall apply. Also, where the requirements of the AHJ are more stringent than these codes/standards, the more stringent requirement shall apply.
   7. The emergency responder radio system must pass the field quality control testing indicated in this specification section, and any other testing that is required by the AHJ.
   8. The emergency responder radio system shall enhance the radio signal strength as follows (except where the requirements of the AHJ are more stringent in which case the more stringent requirement shall apply):
      a. Minimum Inbound Signal Strength: The minimum inbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the AHJ. The inbound signal level shall be sufficient to provide not

less than a Delivered Audio Quality (DAQ) of 3.0 for either analog or digital signals. In addition to this, the RSSI shall be -95dBm or better.

b. Minimum Outbound Signal Strength: The minimum outbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the AHJ. The outbound signal level shall be sufficient to provide not less than a Delivered Audio Quality (DAQ) of 3.0 for either analog or digital signals. In addition to this, the RSSI shall be -95dBm or better.

9. The frequencies/channels that shall be enhanced by the emergency responder radio system shall be coordinated with the AHJ.
10. The emergency responder radio system shall comply with the requirements of the AHJ, and shall be inspected/approved by the AHJ.
11. All devices/equipment shall be comply with the applicable FCC regulations.
12. A battery backup system shall be provided to provide backup power for the entire emergency responder radio system. The battery backup system shall comply with all of the following (except where the requirements of the AHJ are more stringent in which case the more stringent requirement shall apply):
    a. The battery backup system shall be dedicated to the emergency responder radio system.
    b. The battery backup capacity shall be capable of operating the emergency responder radio system at 100 percent system capacity for a duration of not less than 12 hours.
13. Coaxial cables entering the building shall be grounded per NEC Article 820.
14. The emergency responder radio system shall be powered from the power supplies with battery backup. The power supplies shall be powered from dedicated 120VAC, 20A branch circuits. Where there is a generator at the building, the branch circuits shall be connected to the panelboards which are powered by the generator, when there is a loss of normal utility power. Provide 120VAC, 20A circuit breakers (short circuit current rating of the breaker shall not be less than the short circuit current rating of the associated panelboard) at the panelboards. Provide branch circuit wiring/conduit in accordance with NEC requirements, and make the power supplies fully operational.
15. 120VAC surge protective devices shall be provided at the input to each device/equipment that has a 120VAC input.
16. Provide fire alarm monitor modules, communications equipment, and associated wiring/conduit for the following signals, and connect these modules/equipment/wiring/conduit to each equipment which has the corresponding output signal:
    a. Emergency Responder Radio System, loss of normal AC power supply
    b. Emergency Responder Radio System, battery charger failure
    c. Emergency Responder Radio System, malfunction of the donor antenna
    d. Emergency Responder Radio System, failure of active RF-emitting device
    e. Emergency Responder Radio System, low-battery capacity at 70-percent reduction of operating capacity
    f. Emergency Responder Radio System, failure of critical system components
    g. The communications link between the fire alarm system and the emergency responder radio enhancement system.

PART 3 - EXECUTION

3.1 APPLICATION

A. An Emergency Responder Radio System shall be provided for the building.

3.2 RADIO SIGNAL TESTING

A. Radio signal testing shall be performed prior to the installation of the Emergency Responder Radio System. The results of the testing shall be submitted to the owner and the permit department for review, prior to installation of the Emergency Responder Radio System.

B. Radio signal testing shall be performed after the installation of the Emergency Responder Radio System. The results of the testing shall be submitted to the owner and the permit department for review.

3.3 INSTALLATION

A. Identify system components, wiring, cabling, and terminals. Mark each cable termination with a unique identification tag which shall match up with the tag indicated in the as-built drawings.

B. Provide bushings at all raceways and boxes to protect all wires and cables from abrasion.

C. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
4. Monitor cable pulling tensions.

E. Install cables and raceway parallel and perpendicular to surfaces or exposed structural members and follow surface contours where possible.

F. Do not install any item (equipment, wiring, cables, raceway, etc.) in hazardous (classified) locations.

G. Seal and make watertight all exterior wall penetrations.

H. Separation of Wires: Comply with TIA/EIA-569-A rules for separating copper communication cabling from potential EMI sources, including electrical power lines and equipment.

I. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect panels.

J. Use splice and tap connectors compatible with media types.

K. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

L. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance during the startup, testing, and programming of the system.

M. Software Updates: Provide software updates for a minimum of 2 years after substantial completion. Software updates shall include all patches and updates.

3.4 FIRESTOPPING

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

B. Install UL Listed Firestopping Material in accordance with the manufacturer's recommendations, and UL's requirements.

3.5 IDENTIFICATION

A. Cables and equipment shall be provided with identification labels that is consistent from end-to-end. The labels shall allow personnel to identify which cable and equipment are associated together. The cables shall be labeled at each end.

B. Location of Cable Labels: Label each cable as follows:
1. Provide cable labels within 4 inches of each splice, termination and tap.
2. Provide cable labels at each cabinet, and each pull/junction/outlet box.
3. Provide cable labels at each equipment.

C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish a hardcopy and electronic copy of final comprehensive schedules for Project, in software and format selected by Owner.

D. Provide an identification label on each equipment, indicating the equipment name. Label shall be weatherproof and fade resistant. Text shall be 1-inch high.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation and supervise pretesting, testing, and adjusting of system.

B. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.

C. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements.

D. Radio signal testing (to be performed before and after installation of the Emergency Responder Radio System) shall be performed by a qualified Radio Signal Testing Company. The radio signal testing shall comply with the following:
1. Comply with the following testing standards unless the requirements of the AHJ are more stringent, in which case the more stringent requirement shall apply:
   a. Comply with the applicable codes and the requirements of the AHJ.
   b. All floors of the building shall be tested for radio signal strength. Each floor of the building shall be divided into a grid of squares. Each grid square shall not be greater than 30' x 30' (where the applicable codes or the AHJ require a smaller grid square, a smaller grid square shall be used). For example, if a building floor measures 60' x 60', there shall be a minimum of 4 grid squares. The columns of the grid shall be labeled with letters (A, B, C, etc), while the rows of the grid shall be labeled with numbers (1, 2, 3, etc.), so that it becomes easy to identify and tabulate the test results. A radio signal test shall be conducted in the center of each grid square to and from the outside of the building. A radio signal test shall

also be conducted from each critical area to and from the outside of the building. A radio test result list shall be attached at the end of the floorplans, which indicates each grid square, identified with the column/row letter/number and the building/floor; and, each critical area. The list will indicate the dBm level and DAQ level test result of each grid square and critical area; whether or not the grid square and critical area passed the radio signal test; and, any other test result required by the AHJ. Where the AHJ requires that additional areas be tested, test the additional areas in accordance with the requirements of the AHJ.

2. Submit a test report. At a minimum, the test report shall include the following:
   a. Qualification data of the testing company, including all licenses and certifications that are required by this specification section; and, the applicable codes and industry standards.
   b. Product data, screenshots, and calibration data for test instruments indicating that the test instruments are suitable for the intended use, and have been calibrated within the last 12 months of the testing, or within a time period determined by code or industry standards, whichever is more stringent.
   c. Project experience of testing company in the local jurisdiction where the project is located.
   d. Testing standards, including minimum signal strength, minimum audio quality, and test frequencies used. The test frequencies shall include the frequencies used by local jurisdiction's first responder agencies, including but not limited to, the fire department.
   e. Provide a summary page indicating locations where the radio signal testing shows test results that do not meet the requirements of this specification section.
   f. Test procedures, including detailed step-by-step description of how the test will be conducted.
   g. Test duration, indicating the estimated time it will take to finish the testing.
   h. Floorplan with grids and list with radio signal test results for each grid square. Radio signal test results for each critical area.
   i. Summary of findings, including areas where radio signal strength is inadequate, and whether or not the building passed/failed the tests. The summary shall indicate which grid square and which critical area have failed the radio signal test. Indicate in the summary where the following criteria are not met (where the applicable codes or the AHJ have a more stringent requirement, the more stringent requirement shall apply):
      1) RSSI: -95dBM minimum
      2) DAQ: 3.0 minimum

E. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.

F. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

G. Remove and replace malfunctioning items and retest as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service and initial system programming.

B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.8 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.9 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

3.10 DEMONSTRATION AND TRAINING

A. Provide demonstration and training for Owner's operating and maintenance personnel. Update the wiring diagrams and floorplans for as-built conditions and turn over three (3) copies for the Owner's use and records.

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shut down, usage, software use, servicing, adjusting and preventive maintenance. Provide a minimum of 8 hours training.

2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.

3. Schedule training with owner with at least 7 days' advance notice. Provide a written notice of the training schedule.

B. Training shall include, but not be limited to, the following:

1. Restarting the system

2. Turning the system on and off.

3. Describe work or equipment that could interfere with the proper operation of the system, and how to prevent interference.

4. Go step-by-step through the operations and maintenance manuals.

C. The demonstration and training shall be video recorded onto USB flash drives by a professional camera firm. Provide 3 copies of each USB flash drive.

END OF SECTION

SECTION 28 16 00 - INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUBMITTALS

A. Product Data: Include data on features, ratings, and performance for each component specified.

B. Shop Drawings. A complete set of shop drawings shall be supplied. This package shall include but not be limited to:
1. Control panel wiring and interconnection schematics. Contractor is responsible for verifying that all the voltages, inputs and outputs are compatible with each other.
2. Complete point to point wiring diagrams.
3. Riser diagrams.
4. Complete floor plan drawing locating all devices and equipment in 1/8" = 1'-0" scale plan. Show the placement of each individual device/equipment as well as raceway size/ routing, junction box size/location, and wire/cable size/type/quantity/color/routing.
5. Show elevation drawing of all equipment.
6. Detailed system operational description.
7. Complete system bill of material.

C. Operation and Maintenance Data

D. System Operation: Provide a detailed description of the system operation, including but not limited to the following:
1. Indicate when an alarm or supervisory signal is generated.
2. Indicate what data is stored on the control panel.

E. System Calculations
1. Provide battery sizing calculations for the standby batteries.

F. Voltage Drop Calculations
1. Provide voltage drop calculations to show that adequate voltage is provided at each equipment, in order to maintain proper equipment operation.

G. Load Calculations
1. Provide load calculations to show that power supplies and other sources of power are adequate to provide power for loadside equipment.

H. Field quality control test reports

I. Equipment and cable identification/labelling schedule

J. Qualifications of persons working on the project.

1.3 QUALITY ASSURANCE

A. A Systems Integrator shall integrate all the different components of the system, and shall make sure that the system is complete and fully operational in accordance with the contract documents, and the applicable codes. Subject to compliance with the requirements indicated in the contract documents, Systems Integrators who may submit qualifications for the project, include, but are not limited to, the following: Ark Systems, Inc.

B. Systems Integrator Qualifications:
1. An experienced equipment installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, and whose work has resulted in construction with a record of successful in-service performance.
2. Certified by the equipment manufacturer to perform the work required by the contract documents.
3. Capable of sizing and selecting different components of the system (including, but not limited to, the wiring) to ensure that all equipment are compatible and suitable for use with each other.
4. Capable of performing all the calculations required by the manufacturer, industry standards, and the contract documents.

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

D. Comply with NFPA 70.

E. Comply with NECA 1.

1.4 COORDINATION

A. Coordinate the equipment indicated in this specification section with all other equipment and systems it connects to. All input/output/communications interfaces/modules shall be compatible and suitable for use with each other.

B. Coordinate programming of system with the preferences of the owner. Comply with the owner's requirements, except where it conflicts with the applicable codes or the requirements of the authorities having jurisdiction.

C. Where equipment are connected to the data network system, coordinate all network settings/configurations with the owner's IT (Information Technology) department.

D. Coordinate line voltage power requirements prior to starting any work to ensure that power is provided to all equipment. The contractor shall provide line voltage power to all equipment that require it, in accordance with the manufacturer's recommendations and NEC requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Where the contract documents specifies a product name, model, or manufacturer, this product shall be considered as the basis-of-design product. The contractor shall provide the basis-of-design product or approved equal. All products shall be submitted for review and approval by the design team.

2.2 GENERAL

A. The contractor shall provide all labor, software, programming, materials, equipment, hardware, mounting, wiring, conduit, junction boxes, power supplies, transformers, batteries, equipment enclosures (all equipment shall have enclosures), and accessories as required for a complete and fully operational system. The contractor shall provide all startup and testing as required, in order to confirm that the system operates in accordance with the contract documents. The system shall comply with all applicable codes, the manufacturer's recommendations, and the requirements of the authorities having jurisdiction.

B. Where licenses are required to install, operate, and maintain the system, provide a minimum of 2 licenses, except where more licenses are required elsewhere in the contract documents, in which case, the larger quantity shall apply. Each license shall be capable of being used locally (at the building), or remotely (in remote facility through the internet).

C. Batteries shall be provided for the entire system to act as emergency/standby/backup power. The batteries shall provide emergency/standby/backup power for not less than 24 hours of supervisory, followed by 5 minutes of alarm. Where a longer duration is indicated elsewhere in the contract documents, the longer duration shall apply. Battery chargers and battery enclosures shall be provided for the batteries as required.

D. Provide the following spare parts:
   1. Provide a 10% spare fuses for each type of fuse. Fuse shall be provided in a box that is labeled to indicate which types of equipment will use the fuse.

2.3 INTRUSION DETECTION CONTROL PANEL

A. Provide DMP XR550 Control Panel with gray enclosure. The control panel shall have the following features:
   1. Select Area, All/Perimeter or Home/Sleep/Away operation
   2. 32-individual reporting areas with common areas
   3. Up to 96superviseddoor access points and/or keypads
   4. Up to 16 supervised keypads, seven of which can be wireless
   5. 32-character names available for user, zone, area, profiles and group names
   6. Up to four profiles per user
   7. Fully supervised network, cellular and Wi-Fi communication
   8. Communications Diagnostics check network and cellular communication status from the keypad
   9. Eight communication paths between the panel and monitoring center
   10. Flexible system arming features with instant arming option
   11. Lockdown operation from keypad
   12. 10,000 user codes with 99 profiles and temporary codes
   13. 506 outputs

14. 12,000 event buffer
15. Built-in phone line monitor
16. UL Listed to the following standards: UL 294, UL 365, UL 609, UL 864, UL 985, UL 1023, UL 1076, UL 1610, and UL 1635.

B. The control panel shall be provided with the following interfacing equipment:
1. Cellular interface: The control panel shall incorporate a cellular communicator that shall allow it to automatically dial out to a remote monitoring facility, for alarm, trouble, and supervisory signals.
2. Ethernet Interface: The control panel shall incorporate a data jack that shall allow it to communicate with remote computers within the building or outside the building through the internet.

C. The control panel shall be accessible via the DMP Virtual Keypad App. The contractor shall install the App on 10 of the owner's computers or mobile devices. The app shall allow the owner to arm/disarm the system, and check for zone status.

D. Provide zone expander modules (multi-point zone expander modules, unless otherwise noted) as required to accommodate all the devices indicated in the contract documents, whether or not the modules are indicated in the drawings. The modules shall be connected to the control panel, and shall be powered by the control panel. Provide enclosures for the modules as required.

E. Provide UL Listed Class 2 rated transformer for the control panel. Provide battery backup for the control panel, and all equipment powered from it. Provide batteries/chargers and associated enclosures as required to comply with the battery backup requirements indicated in the contract documents.

F. Provide remote access/programming software and associated hardware, to allow access/programming of system via a remote computer.

G. Enclosure dimensions shall not exceed 17.5" wide x 32" high x 4" deep. Provide multiple enclosures as required to accommodate the equipment required by the contract documents.

2.4 ENTRY KEYPAD

A. Provide DMP 7060-W Thinline LCD Keypad. The keypad shall have the following features:
1. Visual and audible alarm notification
2. Silence alarm while system remains armed
3. Large, 32-character Liquid Crystal Display (LCD)
4. Custom 16-character home or business name (contractor shall program the name as directed by the owner)
5. Keypad and log backlighting turns red in alarm conditions
6. User-adjustable brightness, tone and volume controls
7. Supports "IUs this a false alarm?" and Cancel/Verify features
8. Built-in diagnostics for ease of service
9. View system events/user activity through keypad display
10. AC power and Armed LED
11. Displays time of day, armed zones, and armed areas

B. The keypad shall be connected to the intrusion detection control panel, and shall be powered by the intrusion detection control panel. Provide backbox/enclosure for the keypad as required.

C. Dimensions of keypad shall not exceed 7" wide x 5.25" high x 0.5" deep.

2.5 PANIC B UTTON

A. Provide Ademco 269R Hardwired Hold-UP switch with the following features:
1. Stainless steel cover
2. Silent operation
3. Switch type: Plunger type DPDT
4. Switch action: Selectable latching or momentary
5. Switch rating: 0.2A @ 30VDC max
6. Operating temperature: 14 to 140 degrees F
7. UL Listed

2.6 120VAC SURGE PROTECTIVE DEVICE

A. Provide Ditek DTK-120HW Surge Protective Device (SPD) with the following features:
1. Voltage configuration: Single phase (2 wire plus ground), 120VAC
2. MCOV: 150VAC
3. Voltage Protection Rating: 700V L-G, L-N; 1500V N-G
4. Suitable for use with 120V, 20A circuit breakers
5. NEMA 4X weatherproof enclosure
6. Surge Current Rating : 50,000
7. Short Circuit Current Rating: 100,000A
8. Nominal Discharge Current Rating (In): 10kA
9. UL 1449 Listed
10. SPD Type 1
11. 10 Year Warranty
12. Operating Temperature: -31 to 176 degrees F
13. Maximum Humidity: 95% non-condensing

2.7 DOOR CONTACT

A. Provide Interlogix model 2507A-L with the following features:
1. UL Listed
2. Loop Type: Open or Closed
3. Electrical Configuration: Single Pole Double Throw
4. Gap Distance (Make): 3"
5. Lead Type: 3' stainless steel armored cable
6. The contact shall be a hermetically sealed reed switch nominally 3"L x 1"H x 0.5"D with matching actuating magnet. Mounting holes shall be on 2" centers. Contact and magnets shall be in brushed anodized aluminum tube housing. Right angle mounting bracket shall b furnished with contact.

2.8 MOTION DETECTOR

A. Provide Bosch Security Systems ISC-CDL1-W15G Motion Detector with the following features:
1. Detector General Description
a. The product specified is a TriTech+ detector incorporating PIR signals with microwave Doppler radar into an intelligent algorithm to provide accurate and reliable alarm decisions. The product is designed for commercial indoor applications and is built with a sealed optic chamber to provide immunity to drafts and insects. The unit consists of a self-locking two-piece enclosure with a built in removable lift gate terminal block and a bi-axial bubble level to help simplify the installation. The detector incorporates advanced algorithms that integrate the data

from four different sensors to ensure alarm conditions are based on precise information.

2. Detector Requirements
   a. The specified detector shall intelligently combine microwave Doppler radar technology with PIR first step processing algorithm to provide accurate and reliable alarm decisions.
   b. The detector shall incorporate microwave noise adaptive processing to reduce false alarms from background disturbances.
   c. The detector shall be available in 10.525 GHz, 10.588 GHz and 9.350 GHz microwave models as required by the application.
   d. The detector shall consist of a self-locking two-piece enclosure with a removable lift gate terminal block and a built in bi-axial bubble level to help simplify the installation.
   e. The detector shall be built with a sealed optic chamber to provide false alarm immunity to drafts, and insects.
   f. The detector shall be designed to provide PIR coverage in the event the microwave subsystem fails.
   g. The detector shall contain a light emitting diode (LED) that adjusts automatically to the surrounding light level. The LED shall indicate dual alarms. The LED may be enabled or disabled locally at the detector via DIP switch.
   h. The detector shall provide a cyclic automatic self test every 7 hours. The detector shall have the ability to announce a self-test fail condition by flashing the LED.
   i. The detector shall provide input power supervision that causes the LED to flash when the power is lower than 6.5 Volts.
   j. The detector shall incorporate different selectable resistor values to help simplifying the installation by eliminating the need to place external end-of-line resistors into the terminal blocks.
   k. The detector shall be designed to provide Radio Frequency Interference (RFI) immunity by causing no alarm on critical frequencies in the range from 150 kHz to 2.7 GHz at field strengths less than 10 V/m.
3. Sensor Technology Requirements
   a. The detector shall incorporate specific technology that uses an internal microprocessor to gather, analyze, and compare the data from four separate sensors to make the most intelligent alarm decisions. The data processed from the microprocessor shall be from a pyroelectric sensor, a Doppler microwave sensor, a room temperature sensor, and a light level sensor.
   b. The detector shall also incorporate optical technology that uses high-quality Fresnel lens with two specific focal lengths to provide rated range and look down coverage. The detector applies the two focal lengths to 29 detection zones.
   c. The detector shall provide active white light suppression capable of measuring the light intensity directed at the face of the unit, and use the data gathered by the sensor to eliminate false alarms caused by the bright light source. False alarms shall not be caused from bright light sources up to 10,000 lux.
   d. The detector shall provide dynamic temperature compensation that adjusts the PIR sensitivity to detect human body heat accurately to avoid false alarms and deliver consistent catch performance at all operating temperatures.
4. Outputs
   a. The detector shall provide a cover and wall tamper switch with a normally closed contact that opens to notify the control panel in the event the cover is removed or the detector is separated from the wall. The contacts shall be rated at 2.5W, 25 VDC, 100 mA maximum.
   b. The detector shall provide a solid state relay that is power supervised and uses less current and provides longer standby capacity than a mechanical relay. The solid state relay shall be used to send a silent alarm output signal. Rating of the relay shall be 2.5W, 100 mA, 25 VDC, with resistance less than 10 ohms.

c. The detector shall provide a solid state relay with normally-closed (NC) contacts that shall be used as a trouble indicator. Rating of the relay shall be 2.5W, 100 mA, 25 VDC, with resistance less than 10 ohms.

5. Coverage and Installation
   a. The detector shall provide 15 m x 15 m (50 ft x 50 ft) field of coverage:
   b. The detector shall incorporate flexible mounting height, allowing it to be mounted at a height between 2.3 m to 2.7 m (7.5 ft to 9 ft) and require no adjustments.
   c. The detector shall utilize a self locking enclosure, with removable terminal strip, bi-axial bubble level and protective cover over the electronics and optics to ensure fast and reliable installation.
   d. The contractor shall provide one of the following for each detector, as required to match with the mounting location and area to be monitored (the contractor shall field survey and verify mounting requirements in the field):
      1) A Gimbal-mount bracket (Bosch Security Systems B328) that mounts on a single-gang box and allows rotation of the detector.
      2) A Low profile plastic wall swivel mount bracket (Bosch Security Systems B335-3). The mount allows a vertical pivot range of +10° to -20° and a horizontal pivot range of ±25°.
      3) A plastic universal swivel bracket for ceiling mounting (Bosch Security Systems B338). The mount allows a vertical pivot range of +7° to -16° and a horizontal pivot of ±45°.
6. Certifications and Approvals
   a. The detector shall be UL Listed
   b. FCC Part 15 Class B
7. Mechanical Specifications
   a. Dimensions: 120 mm x 69 mm x 55 mm (4.7 in. x 2.7 in. x 2.15 in.)
   b. Material: High impact ABS plastic
   c. Color: white
8. Electrical Specifications
   a. Operating Voltage: 9 VDC to 15 VDC
   b. Current (maximum): less than 35 mA
   c. Current (Standby): less than 20 mA
9. Environmental Specifications
   a. Temperature, Operating and Storage: 0°C to +49°C (+32°F TO +120°F)
   b. IP Rating: IP41 / IK04 (EN60529, EN62262)
   c. Relative humidity: 0 to 93%, non-condensing

2.9 POWER SUPPLY

A. Provide Altronix AL300ULPD8CB with the following features:
1. Provided with batteries sized and selected as required to comply with the battery backup requirements indicated in the contract documents.
2. UL 294 Listed; UL 603 Listed; UL 1069 Listed; and, UL 1481 Listed
3. Eight (8) Class 2 Rated power limited outputs, 12VDC or 24VDC outputs.
4. Filtered and electronically regulated DC output
5. Eight power outputs (unswitched) (PTC protected outputs are rated 2.5 amp).
6. Build-in charger for sealed lead acid or gel type batteries.
7. Automatic switch over to standby battery when AC fails
8. Zero voltage drop when unit switches over to battery backup
9. Thermal and short circuit protection with auto rest
10. AC input and DC output LED indicators
11. AC fail supervision (form "C" contact)
12. Battery fail and battery presence supervision (form "C" contact)
13. Dimensions shall not exceed 13.5"H x 13"W x 3.25"D

2.10 CELLULAR ALARM COMMUNICATOR

A. Provide DMP 263LTE-V/381-2 cellular alarm communicator with the following features:
   1. Powered by 12VDC or 24VDC from the intrusion detection system
   2. LTE communications

2.11 OUTDOOR ANTENNA

A. Where the contract documents require an outdoor antenna, or where an antenna is required to be installed outdoors, comply with the following:
   1. The antenna shall have the following features:
      a. Shall be UL listed
      b. Shall be suitable for outdoor conditions and wet locations
      c. Shall be provided with compatible mounting brackets
      d. Shall be suitable for the intended use/location.
   2. Provide UL listed cable (suitable for both indoor and outdoor conditions, compatible with both wet and dry locations, sunlight resistant) in 1" conduit minimum, from the cellular alarm communicator to the antenna. The outdoor end of the conduit shall be formed into a "gooseneck" so that the bottom of the conduit opening faces the ground. Conduit opening shall be capped/sealed with UL listed cable glands and bushings, which are weatherproof/watertight and suitable for the intended use/location.
   3. Provide UL listed grounding block (suitable for outdoor conditions and wet locations) at a location before the antenna cable enters the building. The grounding block shall be compatible with the associated cable/cell phone signal/frequency. Ground wire terminal shall be compatible with the associated ground wire.
   4. Provide multiple antennas as required by the cellular alarm communicator. Each antenna shall have its own dedicated set of mounting brackets, cables, conduit, and grounding blocks.

2.12 WIRING

A. All low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring shall be Plenum Rated (UL Type CMP). Wires shall be sized and selected such that proper operation of the system is achieved. Excessive voltage drop that can adversely affect proper operation of any component in the system shall be avoided.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Provide junction boxes as required, in accordance with the NEC and the manufacturer's recommendations.

B. Wiring methods for low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring:
   1. In the succeeding paragraphs, "raceway" shall mean conduit; and, minimum conduit size shall be ¾", unless otherwise noted and except as follows:
      a. Where surface raceway is required elsewhere in the contract documents, "raceway" shall mean surface raceway.

2. Wiring that is exposed, concealed inside walls/floor, or concealed above inaccessible ceilings:
   a. All wiring shall be installed in raceway.
3. Wiring that is concealed above accessible ceilings:
   a. All wiring shall be installed in raceway, unless otherwise noted and except as follows:
      1) Raceway may be omitted where all of the following conditions are met:
         a) Wiring is used for Communications Circuits or Class 2 Circuits.
         b) Wiring is used in dry locations.
         c) Wiring is used in aboveground applications.
         d) Wiring is not subject to physical damage.
         e) Wiring is supported and secured at intervals which do not exceed 3 feet.
         f) Wiring is supported by hangers and supports from the building structure.
         g) Wiring is not laid on ceiling tiles.
         h) Wiring is not fastened in a manner that puts tension on the wiring.
         i) Wiring is plenum rated (UL Type CMP).
         j) Wiring is supported by UL Listed Metal J-Hooks (with rounded edges and integral cable retainer metal clip) and secured together with plenum rated nylon straps or clamps (the use of stapes is prohibited).
         k) Wiring is concealed above accessible suspended ceilings (this includes, but is not limited to, ceiling spaces above grid type ceilings with removable ceiling tiles).
         l) Raceway is not required by the NEC.

C. Adjust exact location of sensors so that their sensor coverage is not blocked by raceways, boxes, and other equipment.

D. Provide CAT6 data cable from each control panel to the network switches, to allow the intrusion detection system to be monitored and controlled through the local area network by a computer with the intrusion detection software (software provided by the contractor). Coordinate exact location of the network switches in the field. All work shall comply with the manufacturer's recommendations, the NEC, and the contract documents.

E. All junction box covers shall be painted BLUE, and labeled "IDS".

F. Provide multi-point zone expander modules to interface each of the following intrusion detection devices with the intrusion detection control panel: door contacts, panic buttons, motion detectors, and other intrusion detection devices. The multi-point zone expander modules shall be located next to the intrusion detection control panel, unless otherwise noted.

G. Coordinate electrical power supply connection type with the equipment. Where the equipment requires a receptacle connection, provide a receptacle. Where the equipment requires a hardwired connection, provide a hardwired connection. Coordinate all work with the manufacturer and the installation manuals. All work shall comply with the NEC, the manufacturer's recommendations, and the contract documents.

H. Provide a 120VAC Surge Protective Device (SPD) at each equipment that requires 120VAC power. Provide a dedicated SPD for each equipment, whether or not the SPD is indicated in the drawings. Provide junction boxes, wiring, and conduit as required to connect the SPD to the equipment. The SPD shall be located adjacent to the equipment. All work shall comply with the manufacturer's recommendations and NEC requirements.

I. All connections to the intrusion detection devices shall be supervised. Provide end-of-line resistors as required.

J. Where low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio wiring, enter or pass through boxes, enclosures, and furniture/fixtures/equipment, provide grommets and bushings in accordance with the manufacturer's recommendations and NEC requirements.

3.2 INSTALLATION

A. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

B. Cables shall have a minimum separation of 12 inches from 120V or higher power wiring. Cables shall have a minimum separation of 12 inches from light fixtures.

C. All wall and floor penetrations shall be sleeved. All conduit and sleeve ends must have bushings to prevent chafing. Where a conduit or other through-penetration device is installed through a fire rated assembly, the opening around the sleeve and the hole through the sleeve shall be sealed with an Underwriters Laboratory approved fire rated sealant material after the cables have been installed.

D. Install cables without damaging conductors or jacket.

E. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

F. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
4. Monitor cable pulling tensions.

G. Install cables parallel and perpendicular to surfaces or structural members and follow surface contours where possible.

H. Wiring within Wiring Closets and Enclosures: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

I. Separation of Wires: Comply with TIA/EIA-569-A rules for separating unshielded copper telephone and data communication cabling from potential EMI sources, including electrical power lines and equipment.

J. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect panels.

K. Use splice and tap connectors compatible with media types.

L. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

M. In the communications equipment room, install a 5-foot- long service loop on each end of cable.

N. Cable support inside wiring closets, telecommunications closets, data closets:
   1. Support horizontal and backbone cabling from the fire retardant plywood board in each closet.
   2. Provide cable ties and cable tie mounts to support the horizontal and backbone cabling from the plywood board. Provide cable ties every 3".
   3. Cable tie mount shall be manufactured by Panduit or approved equal and shall use galvanized steel screws as the mounting method. Cable tie mount shall be UL Recognized. Cable tie mount size shall be suitable for the cables being supported.

O. Install all devices and equipment in accordance with the manufacturer's requirements.

P. Prior to installing devices and equipment, the contractor shall coordinate the exact locations where the devices and equipment are being installed with the plan drawings and existing conditions, and shall notify the engineer immediately if there are any issues or conflicts. The coordinated locations shall be indicated in the shop drawing submittals. Where conflicts are found during or after the shop drawing submittal process, but before installation of the devices and equipment, the contractor shall notify the engineer of the conflict, and shall adjust the locations of the devices and equipment, where directed by the engineer to do so. The contractor's bid price shall include adjusting the locations of devices and equipment up to 12 feet from the locations on the plan drawings, unless otherwise noted.

Q. All programmable and adjustable settings and sequence of operations shall be coordinated with the owner, and set in accordance with the owner's recommendations. Where the owner has no preference, provide a recommendation for the owner's review. Provide eight (8) hours of on-site meetings with the owner, to discuss and make decisions related to the programmable/adjustable settings/sequence of operations. Prior to meeting with the owner on-site, submit a list of items to be discussed, so that the owner is prepared for the on-site discussions.

R. All equipment shall be installed plumb and level.

S. Clean all equipment in accordance with the manufacturer's recommendations.

3.3 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:
   1. Schedule tests with at least seven days' advance notice of test performance.
   2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   3. Operational Test: Test each system in accordance with the manufacturer's recommendations. Verify that the system is complete and fully operational.

C. Provide the following additional tests and inspections:
   1. Verify that each control unit is in normal condition as detailed in manufacturer's operation and maintenance manual.
   2. Test both primary and secondary power. Verify, by test, that battery backup is capable of operating the system for period and in manner specified.
   3. Test all modes of system operation and intrusion detection at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.

D. Retesting: Correct deficiencies and retest. Prepare a written record of tests.

E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

3.4 STARTUP SERVICE

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

3.5 IDENTIFICATION

A. Each equipment shall be labeled with an address/identification name/number which matches information provided in the submittals or indicated in the drawings. Identify each cable segment between equipment with a unique number corresponding to the address/identification name/number of the associated equipment. Provide a cable schedule which identifies each cable segment and the associated equipment.

3.6 SOFTWARE SERVICE AGREEMENT

A. Provide software technical support as follows:
   1. Beginning at Substantial Completion, service agreement shall include software support for two (2) years.
   2. Technical support shall include the following:
      a. Toll free technical support via phone
      b. Technical support via the internet

B. Provide software upgrade service as follows:
   1. At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   2. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.7 DOCUMENTATION AND TRAINING

A. The contractor shall provide to the owner, complete manuals of the completed system. The manuals shall include operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams, and a manufacturer's suggested spare parts list.

B. In addition to the above manuals, the contractor shall provide the services of the manufacturer's trained representative for a period of eight (8) hours to instruct the owners' designated personnel on the operation and maintenance of the entire system.

C. During the training, the instructor shall provide a laptop that is loaded with the system software, which allows the trainees to monitor and control the system through the network. At the end of the training, this laptop and all software installed on it, shall become the property of the owner, at no additional cost.

D. Training shall be on-site, and hands-on, using the actual equipment installed at the project site.

E. Provide training on how to operate and maintain the system. Also, provide the following additional training:
   1. How to add/remove users from the system.
   2. How to add/edit/remove passwords/access codes.
   3. Owner shall be instructed how to arm and disarm the system. Owner shall be instructed on how to change passwords on the system.
   4. The owner shall be instructed on how to access/program the system remotely (off-site), using all the remote access software provided with the system.
   5. The shall be instructed on how to group detection devices together, and how to arm/disarm different groups together or separately.

END OF SECTION

SECTION 28 23 00 – CCTV SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUBMITTALS

A. Product Data: Include data on features, ratings, and performance for each component specified.

B. Shop Drawings. A complete set of shop drawings shall be supplied. This package shall include but not be limited to:
1. Control panel wiring and interconnection schematics. Contractor is responsible for verifying that all the voltages, inputs and outputs are compatible with each other.
2. Complete point to point wiring diagrams.
3. Riser diagrams.
4. Complete floor plan drawing locating all devices and equipment in 1/8" = 1'-0" scale plan. Show the placement of each individual device/equipment as well as raceway size/ routing, junction box size/location, and wire/cable size/type/quantity/color/routing.
5. Show elevation drawing of all equipment.
6. Detailed system operational description.
7. Complete system bill of material.

C. Operation and Maintenance Data

D. Field quality-control test reports

E. Equipment and cable identification/labelling schedule

F. Qualifications of persons working on the project.

1.3 QUALITY ASSURANCE

A. A Systems Integrator shall integrate all the different components of the system, and shall make sure that the system is complete and fully operational in accordance with the contract documents, and the applicable codes.

B. Systems Integrator Qualifications:
1. An experienced equipment installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, and whose work has resulted in construction with a record of successful in-service performance.
2. Certified by the equipment manufacturer to perform the work required by the contract documents.

3. Capable of sizing and selecting different components of the system (including, but not limited to, the wiring) to ensure that all equipment are compatible and suitable for use with each other.
4. Capable of performing all the calculations required by the manufacturer, industry standards, and the contract documents.

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

D. Comply with NFPA 70.

E. Comply with NECA 1.

1.4 COORDINATION

A. Coordinate the equipment indicated in this specification section with all other equipment and systems it connects to. All input/output/communications interfaces/modules shall be compatible and suitable for use with each other.

B. Coordinate programming of system with the preferences of the owner. Comply with the owner's requirements, except where it conflicts with the applicable codes or the requirements of the authorities having jurisdiction.

C. Where equipment are connected to the data network system, coordinate all network settings/configurations with the owner's IT (Information Technology) department.

D. Coordinate line voltage power requirements prior to starting any work to ensure that power is provided to all equipment. The contractor shall provide line voltage power to all equipment that require it, in accordance with the manufacturer's recommendations and NEC requirements.

1.5 DEFINITIONS

A. CCTV: Closed Circuit Television

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Where the contract documents specifies a product name, model, or manufacturer, this product shall be considered as the basis-of-design product. The contractor shall provide the basis-of-design product or approved equal. All products shall be submitted for review and approval by the design team.

2.2 GENERAL

A. The contractor shall provide all labor, software, programming, materials, equipment, hardware, mounting, wiring, conduit, junction boxes, power supplies, transformers, batteries, equipment enclosures (all equipment shall have enclosures), and accessories as required for a complete and fully operational system. The contractor shall provide all startup and testing as required, in

order to confirm that the system operates in accordance with the contract documents. The system shall comply with all applicable codes, the manufacturer's recommendations, and the requirements of the authorities having jurisdiction.

1. Exceptions:
   a. The following equipment shall be furnished by the owner, and installed by the contractor:
      1) CCTV System Cameras
      2) CCTV System Digital Video Recorders
      3) CCTV System Network Switches
   b. The owner will be responsible for integrating the equipment that are furnished by him, into the IT network.

B. The contractor shall include in his bid price, 24 hours of on-site coordination meetings, and discussions with the owner, over a period of 3 separate non-consecutive days.

2.3 CATEGORY 6 CABLE

A. Provide Category 6 Cable with the following features:
1. ANSI/TIA Category: 6
2. Cable Type: Unshielded
3. Jacket Color: BLUE for data cables, and WHITE for telephone cables
4. Cable shall be Plenum Rated (CMP Type)
5. Remote Powering:
   a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
   b. Power available at PD (Powered Device): 71.3 watts minimum
   c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
6. UL Listed

2.4 CATEGORY 6 PATCH PANELS

A. Provide Category 6 Patch Panels with the following features:
1. ANSI/TIA Category: 6
2. Cable Type: Unshielded
3. Panel Style: Straight
4. Rack Type: EIA 19 INCHES
5. Rack Units: 1
6. Total Ports, quantity: 24
7. Remote Powering:
   a. Fully complies with the recommendations set forth by IEEE 802.3bt Type 4 for the safe delivery of power over LAN cable
   b. Power available at PD (Powered Device): 71.3 watts minimum
   c. Power delivered by PSE (Power Sourcing Equipment): 90 watts minimum
8. UL Listed

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Provide junction boxes as required, in accordance with the NEC and the manufacturer's recommendations.

B. Wiring methods for low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio/speaker wiring:
   1. In the succeeding paragraphs, "raceway" shall mean conduit; and, minimum conduit size shall be ¾", unless otherwise noted and except as follows:
      a. Where surface raceway is required elsewhere in the contract documents, "raceway" shall mean surface raceway.
   2. Wiring that is exposed, concealed inside walls/floor, or concealed above inaccessible ceilings:
      a. All wiring shall be installed in raceway.
   3. Wiring that is concealed above accessible ceilings:
      a. All wiring shall be installed in raceway, unless otherwise noted and except as follows:
         1) Raceway may be omitted where all of the following conditions are met:
            a) Wiring is used for Communications Circuits or Class 2 Circuits.
            b) Wiring is used in dry locations.
            c) Wiring is used in aboveground applications.
            d) Wiring is not subject to physical damage.
            e) Wiring is supported and secured at intervals which do not exceed 3 feet.
            f) Wiring is supported by hangers and supports from the building structure.
            g) Wiring is not laid on ceiling tiles.
            h) Wiring is not fastened in a manner that puts tension on the wiring.
            i) Wiring is plenum rated (UL Type CMP).
            j) Wiring is supported by UL Listed Metal J-Hooks (with rounded edges and integral cable retainer metal clip) and secured together with plenum rated nylon straps or clamps (the use of stapes is prohibited).
            k) Wiring is concealed above accessible suspended ceilings (this includes, but is not limited to, ceiling spaces above grid type ceilings with removable ceiling tiles).
            l) Raceway is not required by the NEC.

C. All junction box covers shall be painted YELLOW, and labeled "CCTV".

D. If mounting height/location of the monitor is not indicated in the drawings, coordinate this with the owner in the field.

E. Where low voltage power/control wiring (Class 2; and, not more than 24V), and phone/data/video/audio wiring, enter or pass through boxes, enclosures, and furniture/fixtures/equipment, provide grommets and bushings in accordance with the manufacturer's recommendations and NEC requirements.

3.2 INSTALLATION

A. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

B. Cables shall have a minimum separation of 12 inches from 120V or higher power wiring. Cables shall have a minimum separation of 12 inches from light fixtures.

C. All wall and floor penetrations shall be sleeved. All conduit and sleeve ends must have bushings to prevent chafing. Where a conduit or other through-penetration device is installed through a fire rated assembly, the opening around the sleeve and the hole through the sleeve shall be sealed with an Underwriters Laboratory approved fire rated sealant material after the cables have been installed.

D. Install cables without damaging conductors or jacket.

E. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.

F. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
4. Monitor cable pulling tensions.

G. Install cables parallel and perpendicular to surfaces or structural members and follow surface contours where possible.

H. Wiring within Wiring Closets and Enclosures: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

I. Separation of Wires: Comply with TIA/EIA-569-A rules for separating unshielded copper telephone and data communication cabling from potential EMI sources, including electrical power lines and equipment.

J. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect panels.

K. Use splice and tap connectors compatible with media types.

L. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

M. In the communications equipment room, install a 5-foot- long service loop on each end of cable.

N. Cable support inside wiring closets, telecommunications closets, data closets:
1. Support horizontal and backbone cabling from the fire retardant plywood board in each closet.
2. Provide cable ties and cable tie mounts to support the horizontal and backbone cabling from the plywood board. Provide cable ties every 3".
3. Cable tie mount shall be manufactured by Panduit or approved equal and shall use galvanized steel screws as the mounting method. Cable tie mount shall be UL Recognized. Cable tie mount size shall be suitable for the cables being supported.

O. Install all devices and equipment in accordance with the manufacturer's requirements.

P. Prior to installing devices and equipment, the contractor shall coordinate the exact locations where the devices and equipment are being installed with the plan drawings and existing conditions, and shall notify the engineer immediately if there are any issues or conflicts. The coordinated locations shall be indicated in the shop drawing submittals. Where conflicts are found during or after the shop drawing submittal process, but before installation of the devices and equipment, the contractor shall notify the engineer of the conflict, and shall adjust the locations of the devices and equipment, where directed by the engineer to do so. The

contractor's bid price shall include adjusting the locations of devices and equipment up to 12 feet from the locations on the plan drawings, unless otherwise noted.

Q. All equipment shall be installed plumb and level.

R. Clean all equipment in accordance with the manufacturer's recommendations.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Provide the following tests and inspections for all cables:
      a. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
      b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   2. Provide the following tests and inspections for Category 6 cables, using test equipment that have been calibrated within the last 12 months prior to the testing (provide proof of calibration)
      a. Wire Map
      b. Length
      c. Propagation Delay
      d. Delay Skew
      e. DC Loop Resistance – recorded for information only
      f. DC Resistance Unbalance – recorded for information only
      g. Insertion Loss
      h. NEXT (Near-End Crosstalk)
      i. PS NEXT (Power Sum Near-End Crosstalk)
      j. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
      k. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
      l. ACR-F (Attenuation to Crosstalk Ratio Far-End)
      m. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
      n. Return Loss
      o. TCL (Transverse Conversion Loss) – recorded for information only
      p. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

B. Retesting: Correct deficiencies and retest. Prepare a written record of tests.

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

3.4 IDENTIFICATION

A. Each equipment shall be labeled with an address/identification name/number which matches information provided in the submittals or indicated in the drawings. Identify each cable segment between equipment with a unique number corresponding to the address/identification name/number of the associated equipment. Provide a cable schedule which identifies each cable segment and the associated equipment.

3.5 DEMONSTRATION AND TRAINING

A. The contractor shall provide to the owner, complete manuals of the completed system. The manuals shall include operating and maintenance instruction, catalog cuts of all equipment and components, as-built wiring diagrams, and a manufacturer's suggested spare parts list.

B. In addition to the above manuals, the contractor shall provide the services of the manufacturer's trained representative for a period of eight (8) hours to instruct the owners' designated personnel on the operation and maintenance of the entire system.

C. Training shall be on-site, and hands-on, using the actual equipment installed at the project site.

END OF SECTION

SECTION 28 31 11 - FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 1 Specification Sections, shall apply to this Specification Section. Division 26 Specification Sections and other Specification Sections where electrical work is indicated or described, shall also apply to this Specification Section.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. Smoke detectors.
4. Heat detectors.
5. Carbon monoxide detectors.
6. Notification appliances.
7. Magnetic door holders.
8. Addressable interface device.
9. Digital alarm communicator transmitter.
10. Cellar alarm communicator
11. Annunciators

B. The Contractor shall furnish all labor, services and materials necessary to furnish and install a complete, functional fire alarm system (System). The System shall comply in respects with all pertinent codes, rules, regulations and laws of the Authority, and local jurisdiction. The System shall comply in all respects with the requirements of the specifications, manufacturer's recommendations and Underwriters Laboratories Inc. (UL) listings.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

C. UL: Underwriter's Laboratories

D. LCD: Liquid Crystal Display

E. ADA: Americans with Disabilities Act

F. ADA Rooms: Rooms that are specifically reserved for people with disabilities

G. EST: Edwards Systems Technology

H. NAC: Notification Appliance Circuit

I. MC: Metal Clad

1.4 REFERENCES

A. All work and materials shall conform to all applicable Federal, State and local codes and regulations governing the installation. If there is a conflict between the referenced standards, federal, state or local codes, and this specification, it is the bidder's responsibility to immediately bring the conflict to the attention of the Engineer for resolution. National standards shall prevail unless local codes are more stringent. The bidder shall not attempt to resolve conflicts directly with the local authorities unless specifically authorized by the Engineer.

B. System components proposed in this specification shall be UL listed to operate together as a system. The supplier shall provide evidence, with his submittal, of listings of all proposed equipment and combinations of equipment. The supplier shall be responsible for filing of all documents, paying all fees (including, but not limited to plan checking and permit) and securing all permits, inspections and approvals. Upon receipt of approved drawings from the authority having jurisdiction, the supplier shall immediately forward two sets of drawings to the Owner. These drawings shall either be stamped approved or a copy of the letter stating approval shall be included.

C. The equipment and installation shall comply with the current provisions of the following codes and standards:
1. NFPA 70 National Electric Code®
2. NFPA 72 National Fire Alarm Code®
3. NFPA 90A Air Conditioning Systems
4. NFPA 101- Life Safety Code®
5. UL 864 - Control Units for Fire Protective Signaling Systems.
6. UL 268 - Smoke Detectors for Fire Protective Signaling Systems.
7. UL 268A - Smoke Detectors for Duct Applications.
8. UL 521 - Heat Detectors for Fire Protective Signaling Systems.
9. UL 228 - Door Closers-Holders, With or Without Integral Smoke Detectors.
10. UL 464 - Audible Signaling Appliances.
11. UL 38 - Manually Actuated Signaling Boxes for Use with Fire-Protective Signaling Systems.
12. UL 346 - Waterflow Indicators for Fire Protective Signaling Systems.
13. UL 1971 - Signaling Devices for the Hearing-Impaired.
14. UL 1481 - Power Supplies for Fire Protective Signaling Systems.

1.5 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

   a. Trained and certified by manufacturer in fire-alarm system design.
   b. NICET-certified fire-alarm technician, Level IV minimum.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
6. Include complete floor plans to indicate equipment and device locations. The address of each addressable device shall be indicated on the floor plans. Show type, size and route of cable and conduits. Floor plans shall be drawn in 1/8" = 1'-0" scale.
7. Include drawings of the graphic annunciator panels
8. Describe sequence of operations of the fire alarm system. Provide a table to show how the fire alarm system will respond to different alarm, trouble, and supervisory conditions.
9. All drawings shall be reviewed, approved, and signed by an individual having a minimum of a NICET Level IV certification in fire protection engineering technology, subfield of fire alarm systems. The date when the drawings were signed shall be provided adjacent to the signature. The NICET certification number and expiration date shall also be provided adjacent to the signature.

D. Qualification Data: For qualified Installer.

E. Field quality-control reports.

F. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," deliver copies to authorities having jurisdiction and include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.

6. Complete information and drawings describing and depicting the entire system as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system at a future date.
7. Complete documentation of system testing.
8. Certification that the entire system has been inspected and tested, is installed entirely in accordance with the applicable codes, standards, manufacturer's recommendations and UL listings, and is in proper working order.
9. As-Built drawings consisting of: a scaled plan of each building showing the placement of each individual item of the Fire Alarm System as well as raceway size and routing, junction boxes, and conductor size, quantity, and color in each raceway. All drawings must reflect point to point wiring, device address and programmed characteristics as verified in the presence of the engineer and/or the end user unless device addressing is electronically generated, and automatically graphically documented by the system.
10. Provide all drawings in standard .DXF format. A bond paper plot of each sheet shall also be provided.
11. Project specific operating manuals covering the installed Life Safety System. A generic or typical owner's instruction and operation manual shall not be acceptable to fulfill this requirement.
12. The application program listing for the system as installed at the time of acceptance by the building owner and/or local AHJ (disk, hard copy printout, and all required passwords).
13. Provide the name, address and telephone of the authorized factory representative.

G. Software and Firmware Operational Documentation:

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

H. A copy of the Fire Alarm System submittal shall be provided to the Permits Department and to the Fire Marshall. Resubmit as required to make clarifications or revisions to obtain approval.

I. Equipment and cable identification/labelling schedule

J. Qualifications of persons working on the project.

K. Provide any and all certifications that are required by the AHJ. Provide any and all certifications that are required to get a permit from the AHJ.

L. Provide a dimensioned coordination drawing showing combined elevations of all equipment at the main entrance, and at the fire alarm control panel location.

1.6 QUALITY ASSURANCE

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

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

C. The fire alarm system installer shall have in-house engineering and project management capability consistent with the requirements of this project. The project shall be supervised by personnel certified by NICET as fire alarm Level IV technicians.

D. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.

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

F. The contractor shall coordinate with the AHJ and the Fire Marshal. The contractor shall provide all certifications, testing, and other requirements that are required by the AHJ and the Fire Marshal. All certifications, testing, and other requirements which are required by the AHJ and the Fire Marshal shall be included in the contractor's bid price.

1.7 COORDINATION

A. Fire alarm system manufacturer shall coordinate wiring and conduit layout and requirements with the Electrical Contractor.

B. Keys for the locks and switches shall be coordinated with the owner and the Fire Department.

C. Comply with the requirements for the Fire Marshall, and the Authority Having Jurisdiction. Program the fire alarm control panel as required.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Smoke, Heat, other Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
   2. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
   3. Keys and Tools: One extra set for access to locked and tamperproofed components.
   4. Audible and Visual Notification Appliances: Five of each type installed.
   5. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The manufacturer of the system equipment shall be regularly involved in the design, manufacture, and distribution of all products specified in this document. These processes shall be monitored under a quality assurance program that meets the ISO 9000 requirements.

B. All System components shall be the cataloged products of a single supplier. All products shall be listed by the manufacturer for their intended purpose.

C. All control panel assemblies and connected field appliances shall be both designed and manufactured by the same company, and shall be tested and cross-listed as to ensure that a fully functioning is designed and installed. The system supplied under this specification shall be a microprocessor-based, system. The system shall utilize independently addressed, microprocessor-based smoke detectors, heat detectors, and modules as described in this specification.

D. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Edwards Systems Technology (EST), (Contact Ark Systems Inc)
2. Notifier
3. Simplex

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Carbon monoxide detectors.
5. Duct smoke detectors.
6. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate alarm system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Duct smoke detector.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Ground or a single break in fire-alarm control unit internal circuits.
4. Abnormal ac voltage at fire-alarm control unit.
5. Break in standby battery circuitry.
6. Failure of battery charging.

7. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Trouble and Supervisory Signal Actions: Annunciate at fire-alarm control unit and remote annunciators. Transmit trouble or supervisory signal to the remote alarm receiving station.

2.3 FIRE-ALARM CONTROL PANEL/SYSTEM

A. The fire alarm control panel shall be manufactured by Edwards Systems Technology (EST). The control panel shall be a multi-processor-based system designed specifically for fire and releasing system applications. The control panel shall be listed and approved for the application standards as listed under the General section.

B. The control panel shall include all required hardware, software and system programming to provide a complete and operational system. The control panel shall assure that life safety takes precedence among all panel activities.

C. The control panel shall include the following capacities:
1. Support up to 380 analog/addressable points (minimum) per panel (1,900 total with 5 networked panels).
2. Support up to 576 chronological events (minimum) in history.
3. Support up to 5 fully supervised network remote annunciators (minimum)
4. Support a DACT (dialer) for off premise notification
5. The control panel shall include the following features:
   a. Provide auto-programing and electronic addressing and mapping of analog/addressable devices.
   b. Provide an operator interface display that shall include functions required for annunciation, command and control system functions.
   c. Provide a discreet system control switch provided for reset, alarm silence, local silence, drill switch, up/down switches, status switch, program switch, enable and disable switches, activate and restore switches, reports switch and test switch.
   d. Provide system reports that provide sensitivity and history details.
   e. Provide an authorized operator with the ability to operate or modify system functions like system time, date, passwords; and autoprogram, enable mapping, restart the system and clear control panel event history file.
   f. Provide an authorized operator to perform test functions within the installed system.
6. Supervision of system components, wiring, initiating devices and software shall be provided by the control panel. Failure or fault of system component or wiring shall be indicated by type and location on the LCD display. Software and processor operation shall be independently monitored for failure.

D. Annunciation
1. The system shall be designed and equipped to receive, monitor, and annunciate signals from devices and circuits installed throughout the building. Manufacturer's standard control switches shall be acceptable if they provide the required operation, including performance, supervision and position indication. If the manufacturers' standard switches do not comply with these requirements, fabrication of custom manual controls acceptable to the owner is required.
2. Receipt of alarm, trouble, and supervisory signals shall activate integral audible devices at the control panel(s) and at each remote annunciation device.
3. The annunciator shall contain the following system status indicators:
   a. 80 character Backlit Liquid Crystal Display.
   b. System Power Indicator – green LED

c. System Common Alarm – red LED
d. System Common Trouble – yellow LED
e. System Common Supervisory – yellow LED
f. System Common Monitor – yellow LED
g. System Ground Fault – yellow LED
h. System CPU Fault – yellow LED.
i. System Disabled – yellow LED.
j. System Test Point(s) – yellow LED.
k. System Reset Switch with Integral yellow LED.
l. System Alarm Silence Switch with Integral yellow LED.
m. System Local Silence Switch with Integral yellow LED.
n. System Drill Switch with Integral yellow LED.
o. System Message Queue Scroll Switches.
p. Additional buttons as required to provide system control and operator functions.

E. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. The display module shall be of membrane style construction with a 4 line by 20 character Liquid Crystal Display. The LCD shall use super-twist technology and backlighting for high contrast visual clarity. In the normal mode display the time, the total number of active events and the total number of disable points. In the alarm mode display the total number of events and the type of event on display. Reserve 40 characters of display space for user custom messages. The module shall have visual indicators for the following common control functions; AC Power, alarm, supervisory, monitor, trouble, disable, ground fault, CPU fail, and test. There shall be common control keys and visual indicators for; reset, alarm silence, trouble silence, drill, and one custom programmable key/indicator. Provide four pairs of display control keys for selection of event display by type (alarm, supervisory, monitor and trouble) and forward / backward scrolling through event listings. The operation of these keys shall be integrated with the related common control indicator that lights when an event of its type is active. Allow the first event of the highest priority to capture the LCD for display so that arriving fire fighters can view the first alarm event "hands free". Provide system function keys; status, reports, enable, disable, activate, restore, program, and test. The module shall have a numeric keypad, zero through nine with delete and enter keys.
2. The display module shall be an EST model 2-LCD.

F. Fire Alarm Circuits:

1. General
   a. All fire alarm circuits shall be supervised and power limited.

2. Initiating Device Circuits:
   a. The Initiating device circuits (IDC) used to monitor manual fire alarm stations, smoke and heat detectors, waterflow switches, valve supervisory switches, fire pump functions, and air pressure supervisory switches shall be Class B (Style "A" or "B"), unless otherwise noted.
   b. The Initiating device circuits shall be EST Signature series modules.
3. 24 VDC Notification Appliance Circuits:

a. 24 VDC Notification appliance circuits (NAC) shall be Class B (Style "Y"), unless otherwise noted. All notification appliance circuits shall have a minimum circuit output rating of 2 amp @ 24 vdc.
b. The 24 VDC Notification appliance circuits shall be EST Signature series modules

4. Signaling Line Circuits:
a. The signaling line circuit shall communicate from a panel/node to analog/addressable detectors, input modules, output modules, isolation modules and notification appliance circuits.
b. Each signaling circuit connected to addressable/analog devices shall provide a minimum of 20 spare addresses. When a signaling line circuit covers more than one fire/smoke compartments, a wire-to-wire short shall not effect the operation of the circuit from the other fire/smoke compartments. The signaling line circuit (SLC) connecting panels and annunciators shall be Class B (style 4), unless otherwise noted.
c. The signaling line circuit connecting to addressable/analog devices including, detectors, monitor modules, control modules, isolation modules, and notification circuit modules shall be Class B (style 4), unless otherwise noted.

G. Serial Interfaces: Two RS-232 ports for printers.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

I. 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.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries shall be sealed and maintenance free.

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

N. Digital Alarm Communicator and Transmitter:
1. The panel shall have a dialer (alarm communicator transmitter (DACT)) module to transmit alarm, supervisory and trouble signals to a Central Monitoring Station (CMS). The DACT shall support dual telephones lines, 20 PPS 4/2

communications, and configured for dual tone multi-frequency (DTMF) or pulse modes. It shall be possible to delay AC power failure reports, auto test call, and site program using a touch tone phone and password.

2. The dialer shall be an EST model DL2.

O. Display

1. System Message Processing and Display Operations:
   a. The system shall allow message routing to be configured to any or all annunciators.
   b. All system printer port shall be configurable to output any combination of alarm, supervisory, trouble, or monitor, event messages.
   c. Each LCD display on each annunciator shall be configurable to display the status of any combination of alarm, supervisory, trouble, or monitor, event messages.
   d. Clear distinction shall be provided between alarm, supervisory, trouble, and monitor status messages.
   e. The system shall provide the ability to retrieve data from the analog/addressable detectors to a PC while the system is on-line and operational in the protected premises. The uploaded data may then be analyzed in a diagnostic program supplied by the system manufacturer.
   f. A standby power supply shall automatically supply electrical energy to the system upon primary power supply failure.

P. Reports

1. The system shall provide the operator with system reports that give detailed chronological description of the last 576 system events. The system shall provide a report that gives a listing of the sensitivity and environmental compensation usage of all of the detectors on the system, or specified analog/addressable circuit.
2. The system report shall also include facility name, compiled date, compiler revision, project revision and report date. The system shall output these reports via the main LCD, and reports shall be capable of being printed on the system printer.

Q. Battery backup:

1. The entire fire alarm system shall have a battery backup system. Batteries shall be sized for 24 hours of standby followed by 15 minutes of alarm. Provide an additional 20% spare battery capacity on top of that.

2.4 BOOSTER POWER SUPPLIES

A. The booster supply must incorporate four independent supervised Notification Appliance Circuits. It shall be possible to configure the NACs to follow the main panel's NAC or activate from intelligent Signature Series modules. The booster NACs must be configurable to operate independently at any one of the following rates: continuous; 120 SPM; or, 3-3-3 temporal. Fault conditions on the booster shall not impede alarm activation of host NAC circuits.

B. Fault conditions detected by the power supply shall open the main fire alarm control panel's NAC. This initiates a trouble condition and eliminates the need to wire a separate trouble signal back to the control panel.

C. Power supply shall have an enclosure.

D. Battery backup shall be provided.

E. Booster Power Supplies shall be EST BPS Series with enclosure and battery backup.

2.5 AUDIO AMPLIFIERS

A. Each audio power amplifier shall have integral audio signal de-multiplexers, allowing the amplifier to select any one of eight digitized audio channels as directed by system programming.

B. Audio amplifiers shall be power limited and protected from short circuits conditions on the audio circuit wiring. Each amplifier output shall provide a selectable 25/70 Vrms output, suitable for connection to emergency speakers.

C. To enhance system survivability in the event of a total loss of audio data communications, all amplifiers shall default to the local "EVAC" tone generator channel. If the local panel has an alarm condition, then all amplifiers will sound the EVAC message on their speaker circuits. In the event of a loss of the fully digitized, multiplexed audio riser data, the audio amplifiers shall automatically default to an internally generated alarm tone which shall sound a 3-3-3 temporal pattern.

D. Amplifiers shall also include a 24 VDC notification appliance circuit rated at 24Vdc @ 3.5A for connection of visible (strobe) appliances. This circuit shall be fully programmable.

E. Manufacturer and Model Number:
   1. Audio amplifiers shall be Edwards 3-ZA series devices.
   2. Audio amplifier panels shall be audio amplifiers that are factory installed in a UL listed enclosure, with the manufacturer's recommended power supplies, battery backup, and other components/accessories, for a complete and fully operational panel.

2.6 MANUAL FIRE-ALARM BOXES or MANUAL PULL STATIONS

A. Provide analog/addressable single action, single stage fire alarm stations at the locations shown on the drawings. The fire alarm station shall be of metal construction and incorporate an internal toggle switch. The station shall be finished in red with silver "PULL IN CASE OF FIRE" lettering. The manual station shall be suitable for mounting on North American 2 ½ (64mm) deep 1-gang boxes and 1 ½ (38mm) deep 4 square boxes with 1-gang covers.

B. The analog/addressable single action, single stage fire alarm stations shall be EST model SIGA-270.

C. Protective Cover for manual pull stations
   1. Protective cover shall be manufactured by Safety Technology International, Inc and shall have the following features:
      a. Tamperproof, clear Lexan polycarbonate shield and frame that fits over manual pull stations
      b. UL Listed
      c. UL Listed for use with manual pull stations
      d. With horn and battery
      e. ADA compliant

f. Provide backbox, spacers, and other accessories as required

2.7 SMOKE DETECTORS

A. Provide Edwards SIGA-OSD smoke detector with the following features:
1. Multi-criteria optical smoke sensing technology
2. Non-volatile memory
3. Electronic addressing
4. Automatic Day/Night Sensitivity Adjustment
5. Bicolor (Green/Red) Status LED
6. Air velocity 0 to 4,000 ft/min
7. Wall mounting: Up to 12 inches from ceiling
8. Environmental compensation: Automatic
9. Approvals: UL 268

2.8 DUCT SMOKE DTECTORS

A. Provide Edwards SIGA-SD with the following features:
1. -20 degrees F to 158 degrees F operating range
2. 100 ft/min to 4,000 ft/min air velocity
3. Status LEDs remain visible through clear assembly cover
4. Environmental compensation with differential sensing
5. UL Listed

B. Remote test switches/LED indicators shall be provided to indicate location of the detector. Remote test switches/LED indicators shall be provided whether or not they are shown in the drawings. Exact location shall be coordinated in the field.

C. Where duct smoke detectors are installed outdoors, are installed above roofs, or are indicated as "OUTDOOR TYPE" in the drawings, provide the following additional items:
1. Provide Edwards SD-PH Protective Housing. The SD-PH is a weatherized housing that prevents condensation on the device by insulating the detectors and providing circulated air from the monitored HVAC duct. All wires that exit the protective housing shall be installed in raceway. The raceway shall be connected to the bottom of the protective housing. The protective housing shall be installed inside a NEMA 3R metal enclosure.
2. Provide NEMA 3R metal enclosure to enclose the entire duct smoke detector and protective housing. The enclosure shall protect the detector and protective housing from rain, snow, etc. Coordinate the size of the enclosure with the size of the detector and protective housing. The enclosure shall have a lockable and hinged accessible cover to access the detector and protective housing. Provide a label on the metal enclosure which indicates the fire alarm device type and address. Wiring shall run in raceway from outside the NEMA 3R enclosure, through a conduit opening in the bottom of the NEMA 3R enclosure, up to the bottom of the Edwards SD-PH Protective Housing. All wiring outside the protective housing shall be installed in raceway.
3. Provide insulation on the inside of the NEMA 3R metal enclosure. The insulation shall not limit access to the detector. The cover of the metal enclosure shall be easily opened and closed without damaging the insulation. The insulation shall not be in contact with live electrical parts, exposed wires, exposed electrical terminations, etc. The insulation shall not be in contact with items which can damage it. Insulation shall be furnished and installed in accordance with the manufacturer's recommendations and applicable codes. The insulation shall be

1" thick K-FLEX DUCT LINER GRAY with PSA (Pressure Sensitive Adhesive), and shall have the following features:

a. It is environmentally friendly as it is free of CFCs, HFCs, HCFCs, PBDES, formaldehyde and fibers
b. An EPA registered antimicrobial agent is incorporated into the product providing additional protection against mold, fungal and bacterial growth.
c. It is UL GREENGUARD Gold Certified for low VOC emissions.
d. When using factory applied PSA (Pressure Sensitive Adhesive) the low temperature limit is -40 degrees Fahrenheit.
e. When the product is installed fully adhered to the insulated surface via the PSA, the high temperature limit is 200 degrees Fahrenheit.
f. The product is used to reduce should transmission and/or retard heat gain/loss and prevent condensation when used as an internal liner on equipment.
g. Flexible (even at low temperatures), durable (non-fracturing) and skin resistant to tearing.
h. The product can be cut manually or by automated equipment.
i. The expanded closed cell structure and unique formulation inherently resists moisture vapor intrusion. For most applications, the insulation needs no additional protection.
j. The insulation has a flame spread rating of 25 or less and a smoke development rating of 50 or less as tested to ASTM E84. It is acceptable for duct/plenum applications, meeting the requirements of NFPA 90A/B.
k. Specification Compliance: ASTM C534 Type 2, Grade 1; ASTM C1534; USDA Compliant; CFIA Compliant; RoHS Compliant; ASTM E84 25/50-rated – tested to UL 723 and NFPA 255; NFPA No. 101 Class A Rating; NFPA 90A, 90B; and UL 94: VO-0, 5VA.
l. Mildew/Fungi Resistance: complies with UL 181, ASTM G21, ASTM C1338
m. Pressure Sensitive Adhesive (PSA): Solvent-free, acrylic dispersion adhesive with high tack, high peel resistance (>= 20N/25mm per DIN EN 1939), high shear adhesion (500g/625mm2 per DIN 1943), and resistance to humidity and aging. Adhesive: 0.07 mm thickness; Support: Scrim; Liner: Poly film release liner, moisture and tear resistant, easy release.
n. Hot Surface Performance (220 degrees Fahrenheit): No Cracking or Delamination when tested in accordance with ASTM C411.

2.9 HEAT DETECTORS

A. Provide Edwards SIGA-HRD heat detector with the following features:
1. Non-volatile memory
2. Electronic addressing
3. Bicolor (Green/Red) Status LED
4. 50 foot spacing
5. 135 degrees F fixt temperature alarm point plus 15 degrees F per minute rate-of-rise alarm point
6. Approvals: UL 521

2.10 SYSTEM CARBON MONOXIDE DETECTOR

A. Provide Edwards SIGA-COD carbon monoxide detector with the following features:
1. Non-volatile memory
2. Electronic addressing
3. Automatic day/nigh sensitivity adjustment

4. Bicolor (green/red) status LED
5. Approvals: UL 2075, Evaluated to the CO alarm sensitivity limits of UL 2034

2.11 DETECTOR BASES

A. Provide standard detector mounting bases (provide trim skirt in finished spaces, and in spaces where the associated junction box is recessed into the wall/ceiling), unless otherwise noted.

2.12 NOTIFICATION APPLIANCES

A. General (signals)
1. All appliances which are supplied for the requirements of this specification shall be UL Listed for Fire Protective Service, and shall be capable of providing the "equivalent facilitation" which is allowed under the Americans with Disabilities Act Accessibilities Guidelines (ADA(AG)), and shall be UL 1971 Listed.
2. All appliances shall be of the same manufacturer as the fire alarm control panel specified to insure absolute compatibility between the appliances and the control panels, and to insure that the application of the appliances are done in accordance with the single manufacturer's instructions.
3. Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purpose intended. All strobes shall be provided with lens markings oriented for wall mounting.
4. All notification appliances shall be red unless noted otherwise on the drawings.
5. The word "FIRE" shall be engraved on the devices.
6. Provide weatherproof devices where indicated on the drawings, and where the devices are located outdoors or in wet locations.
7. Provide wall or ceiling mounted devices in accordance with the drawings. The devices shall be suitable for the intended mounting configuration, per the manufacturer's recommendations and the applicable codes.

B. Horns
1. The horn shall have a minimum of 2 field selectable settings for dBA levels. Horn shall be UL Listed under Standard 464.

C. Speaker
1. The speaker shall have a minimum of 4 field selectable settings for dBA levels. Speaker shall be UL Listed under Standard 1480.

D. Strobes
1. The strobe shall have switch selectable settings for light output. Output shall be rated per UL Standard 1971 for the candela ratings indicated in the drawings. Strobes shall provide synchronized output.

E. Horn-Strobe
1. The combination device shall consists of a horn and a strobe.
   a. The horn shall have a minimum of 2 field selectable settings for dBA levels. Horn shall be UL Listed under Standard 464.

b. The strobe shall have switch selectable settings for light output. Output shall be rated per UL Standard 1971 for the candela ratings indicated in the drawings. Strobes shall provide synchronized output.

F. Speaker-Strobe
1. The combination device shall consist of a speaker and a strobe.
a. The speaker shall have a minimum of 4 field selectable settings for dBA levels. Speaker shall be UL Listed under Standard 1480.
b. The strobe shall have switch selectable settings for light output. Output shall be rated per UL Standard 1971 for the candela ratings indicated in the drawings. Strobes shall provide synchronized output.

2.13 INITIATION AND CONTROL MODULES

A. Intelligent Modules – General
1. It shall be possible to address each intelligent module without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The personality of multifunction modules shall be programmable at site to suit conditions and may be changed at any time using a personality code downloaded from the Analog Loop Controller. Modules requiring EPROM, PROM, ROM changes or DIP switch and/or jumper changes shall not be acceptable. The modules shall have a minimum of 2 diagnostic LEDs mounted behind a finished cover plate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment:
a. Temperature: 32°F to 120°F (0°C to 49°C)
b. Humidity: 0-93% RH, non-condensing

B. Control Relay Module
1. The Control Relay Module shall provide one form "C" dry relay contact rated at 2 amps @ 24 Vdc (0.5 amps at 120VAC) to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers.
2. The addressable control relay circuit module shall be an EST model SIGA-CR.

C. Dual Input Module
1. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types:
a. Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.)
b. Normally-Open Alarm Delayed Latching (Waterflow Switches)
c. Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.)
d. Normally-Open Active Latching (Supervisory, Tamper Switches
2. The intelligent dual input module shall be an EST model SIGA-CT2.

D. Isolator Module

1. The Isolator Module shall be capable of isolating and removing a fault from a class A data circuit while allowing the remaining data loop to continue operating. The module shall be suitable for mounting on North American 2 ½" (64mm) deep 2-gang boxes and 1 ½" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes.
2. The intelligent fault isolator module shall be an EST model SIGA-IM.

E. Single Input Module
1. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types:
   a. Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.)
   b. Normally-Open Alarm Delayed Latching (Waterflow Switches)
   c. Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.)
   d. Normally-Open Active Latching (Supervisory, Tamper Switches)
2. The intelligent single input module shall be an EST model SIGA-CT1.

F. Single Input Signal Module
1. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 personalities, each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" (64mm) deep 2-gang boxes and 1 ½" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The single input signal module shall support the following operations:
   a. Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A, 25Vrms @50w or 70 Vrms @ 35 Watts of Audio)
   b. Telephone Power Selector with Ring Tone (Fire Fighter's Telephone)
2. The intelligent single input signal module shall be an EST model SIGA-CC1.

G. Dual Input Signal Module
1. The Dual Input (Dual Riser Select) Signal Module shall provide two (2) supervised Class B output circuits capable of a minimum of 2 personalities, each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" (64mm) deep 2-gang boxes and 1 ½" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The dual input signal module shall support the following operations:
   a. Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A, 25Vrms @50w or 70 Vrms @ 35 Watts of Audio)
   b. Telephone Power Selector with Ring Tone (Fire Fighter's Telephone)
2. The intelligent single input signal module shall be an EST model SIGA-CC2.

H. Multi-Voltage Control Relay
1. The relay is encapsulated multi-voltage device providing 10 amp form C contacts. The relay may be energized by one of three input voltages: 24VAC, 24VDC or 115VAC.
2. The relay shall support the following operations:
   a. To be provided as required to switch larger currents that cannot be handled by other devices.
   b. To monitor 24VDC voltage.
3. The relay shall be EST model PAM-1.

2.14 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24VDC. Provide power to the door holder from the fire alarm system 24VDC power supplies.
4. Material and Finish: Match door hardware.

2.15 CELLULAR ALARM COMMUNICATOR

A. Provide DMP CellComF-LTE-V cellular alarm communicator with the following features:
1. UL 864 listed
2. Power connection terminal: Powered by 12VDC or 24VDC from the fire alarm system.
3. 2 inputs for phone lines
4. LTE communications
5. RED housing color

2.16 120V SURGE PROTECTIVE DEVICE

A. Provide Ditek DTK-120HW surge protective device with the following features:
1. Voltage configuration: Single phase (2 wire plus ground), 120VAC
2. MCOV: 150VAC
3. Voltage Protection Rating: 700V L-G, L-N; 1500V N-G
4. Suitable for use with 120V, 20A circuit breakers
5. NEMA 4X weatherproof enclosure
6. Surge Current Rating : 50,000
7. Short Circuit Current Rating: 100,000A
8. Nominal Discharge Current Rating (In): 10kA
9. UL 1449 Listed
10. SPD Type 1
11. 10 Year Warranty
12. Operating Temperature: -31 to 176 degrees F
13. Maximum Humidity: 95% non-condensing

2.17 FIRE ALARM LCD ANNUNCIATOR PANEL

A. The annunciator panel shall include an LCD Display mounted inside the enclosure. LCD shall have 4 lines of 20 characters per line. Display shall be capable of supporting custom messages as well as system event annunciation. It must be possible to filter unwanted annunciation of trouble, alarm or supervisory functions.

B. Where the drawings show or indicate that the panel shall be recessed into the wall, provide a panel enclosure that is suitable for recess or semi-flush mounting.

2.18 FIRE ALARM GRAPHIC ANNUNICATOR PANEL

A. General

1. Annunciator shall be UL864 listed.
2. The annunciator shall provide a graphic representation of the facility fire alarm system.
3. The graphic annunciator shall be equipped with a key locked see-through door mounting.
4. The annunciator shall be powered by a battery backed up nominal 24 VDC power source.
5. All communication between the graphic annunciator and the fire alarm control panel shall be digital.
6. Annunciator graphics shall be white artwork on smoked Plexiglas® with high intensity status LEDs mounted behind the Plexiglas. It shall be possible to update the graphic image in the field without replacing the entire graphic.
7. The face of each annunciator shall graphically represent the building using a full floor plan and the area served by the annunciator. The graphic shall comply with the requirements indicated in the contract documents.
8. The contractor's bid price shall include making one field modification of each graphic annunciator panel to add text/graphic or delete text/graphic as directed by the engineer. LED indicators which are not used shall be relabeled to "SPARE" in the field. The field modification shall be provided up to 2 years from substantial completion.

B. The graphic annunciator panel shall comply with all of the following:
   1. The panel shall comply with NFPA, applicable codes, the requirements of the fire marshal, and the requirements of the authority having jurisdiction.
   2. Comply with the following paragraphs where applicable, unless the paragraphs conflict with the requirements of the AHJ. Where the requirements in the following paragraphs conflict with the requirements of the AHJ, the requirements of the AHJ shall take precedence.
      a. The panel shall show the following minimum information:
         1) Annunciator zoning (provide LED lights for each annunciator zone). The annunciator zoning shall be coordinated with the sprinkler zones. Coordinate with the approved sprinkler/fire protection drawings, and the requirements of the authority having jurisdiction.
         2) Detailed floor plan of the entire building, showing all the rooms and floors. Egress routes shall be indicated in arrows on the floor plans.
         3) North arrow
         4) Location of fire alarm control panels
         5) Location of fire department connections
         6) Location of stair towers
         7) Location of standpipe
         8) Location of sprinkler and standpipe control valves
         9) Location of trash and laundry chutes
         10) Location of stairways, hallways, corridors, means of egress, and exits
         11) Location of exit doors
         12) Location of graphic annunciator panel
         13) Location of generators and transfer switches
         14) Location of electrical service
         15) Location of fire walls (indicate fire rating) and smoke barriers
         16) "You are here" indicator
      b. The panel shall have the following minimum LED lights:
         1) Provide one RED LED light inside each annunciator zone on the floor plan (one LED per zone). This shall light up when there is an alarm condition within the annunciator zone. The types of alarm conditions include, but are not limited to, the following:
            a) Manual pull station RED LED

b) Smoke detector RED LED
c) Heat detector RED LED
d) Sprinkler Flow Switch RED LED
e) Carbon Monoxide detector RED LED

2) Provide YELLOW LED light inside each annunciator zone on the floor plan (one LED per zone). This shall light up when there is a supervisory condition within the annunciator zone. The types of supervisory conditions include, but are not limited to, the following:
a) Sprinkler valve tamper switch YELLOW LED
b) Duct smoke detector YELLOW LED

3) Provide Generator and Transfer Switch indicators:
a) Generator running GREEN LED
b) Generator Fault YELLOW LED

4) Provide system trouble YELLOW LED
5) Provide system power on GREEN LED
6) Provide system normal GREEN LED (no alarms, troubles, or supervisory)
7) Provide 2 spare LEDs of each type of color (GREEN, YELLOW, and RED)

c. Provide the following switches:
1) Key operated rest switch
2) Key operated drill switch
3) Key operated trouble local silence (for silencing the annunciator local buzzer) switch
4) Key operated spare switch. Switch shall be marked "SPARE" and can be field programmed for any use.
5) Push-to-test switch for testing the LED lights

3. The graphic annunciator panel floor plans shall be drawn in manner that easily allows the viewer to orient himself as to which direction he is facing. For example, if the viewer is facing the panel and the main entrance door is on the left side of the panel, the main entrance door shall also be located on the left side of the viewer.
4. Provide additional information, indicators, and devices as required by the fire marshal, and the authority having jurisdiction.
5. Where the drawings show or indicate that the panel shall be recessed into the wall, provide a panel enclosure that is suitable for recess or semi-flush mounting.

2.19 FIRE ALARM VOICE MICROPHONE PANEL

A. The panel shall include a microphone, and all pushbuttons, indicators, displays and other accessories that are needed in order to make announcements on the fire alarm speakers.

2.20 FIRE ALARM DOCUMENTS BOX

A. Fire Alarm Documents Box shall Space Age Electronics, Inc Fire Alarm Storage Cabinet RED with the following features:
1. The documents box shall be UL listed, constructed of 18 gauge cold rolled steel. It shall have a red powder coat epoxy finish. The cover shall be permanently screened with 1" high lettering "FIRE ALARM DOCUMENTS" with white indelible ink. The access door shall be locked with a 3/4" barrel lock and the hinge shall be a solid width 12" stainless steel piano hinge. The enclosure will supply 4 mounting holes. Inside the enclosure will accommodate standard 8 1/2" x 11" manuals and loose document records that will be protected within the enclosure.

A legend sheet will be permanently attached to the door for system required documentation. Key contacts and system information. The documents box will have securely mounted inside a minimum of 4 Gigabyte digital flash memory drive with a standard USB B connector for uploading and downloading information. The drive shall not be accessible without tools to any person whom gains access to the records. The enclosure shall also provide 2 key ring holders with a location to mount standard business type cards for key contact personnel.

2. The items that shall be stored in the documents box include, but are not limited to, the following: fire alarm software, business cards for fire alarm system installer, test records, inspection records, service records, systems records, manuals, and folded as-built drawings of the fire alarm system.

2.21 FIRE ALARM METAL CLAD CABLE

A. Cable shall be UL Listed and Rated Type MC (Metal Clad Cable) and Type FPLP (plenum rated). Cable shall 600V rated for Type MC and 300V rated for Type FPLP.

B. Cable shall be red in color.

C. Wiring shall be suitable for the intended use and location, and shall be compatible with the manufacturer's equipment. Wiring shall be furnished and installed in accordance with the manufacturer's recommendations, NEC requirements, and applicable codes.

PART 3 - EXECUTION

3.1 EQUIPMENT APPLICATION/INSTALLATION

A. Cellular Alarm Communicator
1. A cellular alarm communicator shall be provided to allow the fire alarm system to communicate with the remote monitoring facility. Where the communicator is not shown on the drawings, the communicator shall be located in the same room as the fire alarm control panel. Exact location shall be coordinated in the field. Make sure that there is adequate wireless reception wherever the communicator is installed, so that the signal transmission to the remote monitoring facility is clear and reliable.
2. Where telephone wiring is required by the manufacturer between the fire alarm control panel and the cellular alarm communicator, provide 2 sets of telephone wires from the fire alarm control panel to the cellular alarm communicator. Provide all wiring/conduit/equipment to make the fire alarm system capable of communicating with the remote monitoring facility via wireless cellular transmission, in accordance with the manufacturer's recommendations and NEC requirements. Provide not less than 2 years of cellular service and monitoring service, with the cell phone and remote monitoring service companies.

B. Air Handling Unit Shutdown:
1. Duct smoke detectors shall include housing, sampling tube, smoke detector, and remote key-operated test station (with built-in alarm LED indicator). Provide wiring as recommended by the manufacturer in 3/4" conduit from duct smoke detector to remote test station. Remote test station shall be located in an accessible location that can easily be seen.
2. Provide a control module to interlock with the Air Handling Unit.

C. Provide booster power supplies and audio power supplies as required or as indicated. Install power supplies in an accessible location. Do not install power supplies above the ceiling. Where the drawings do not show branch circuits for the power supplies, provide 120VAC, 20A circuit breakers (short circuit current rating of the breaker shall not be less than the short circuit current rating of the associated panelboard) at the nearest panelboard, for the power supplies. Provide branch circuit wiring/conduit from the breaker to the power supplies. Branch circuit wiring/conduit shall be 2#12 & 12G in ¾"C for branch circuits 50' or less in overall length, and 2#10 & #10G in ¾"C for branch circuits more than 50' in overall length, unless otherwise noted.

D. Comply with NFPA 72 for installation of fire-alarm equipment.

E. Install wall-mounted equipment, with tops of cabinets not more than 72 inches above the finished floor.

F. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
4. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

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

H. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

I. Circuit disconnecting means (circuit breakers) for fire alarm control panels, power supplies (booster power supply, audio amplifiers, etc.), and other 120V equipment shall be provided with a red marking, and shall be identified as "FIRE ALARM CIRCUIT CONTROL". The location and circuit number of the breaker shall be labeled on the associated fire alarm control panel, power supply, and other 120V equipment. Field install a circuit breaker handle clamp at the breaker, to prevent the breaker handle from being manually switched to the OFF position. Handle clamp shall not prevent the breaker from tripping. Authorized personnel shall have the capability to remove the handle clamp.

J. Provide an addressable smoke detector above the fire alarm control panels, power supplies, and other 120V equipment, whether or not the smoke detector is indicated in the drawings.

K. Provide a fire alarm control module for each access control panel to unlock all doors in the building in the event of a fire alarm, whether or not the control module is indicated in the drawings. Coordinate with the access control system as required.

L. Provide a fire alarm control module for each public address system shunt trip device to silence the public address system speakers in the event of a fire alarm, whether or not the control module is indicated in the drawings. Coordinate with the public address system as required.

M. All strobes shall flash in synchronization. Provide synchronization modules as required.

N. Where the drawings show a strobe candela rating which is not available, a strobe with the next higher candela rating shall be provided. This rule shall apply to all notification devices with a strobe (including, but not limited to, strobes, horn-strobes, and speaker-strobes).

O. Provide fire alarm documents box adjacent to the fire alarm control panel.

P. Prior to installing devices and equipment, the contractor shall coordinate the exact locations where the devices and equipment are being installed with the plan drawings and existing conditions, and shall notify the engineer immediately if there are any issues or conflicts. The coordinated locations shall be indicated in the shop drawing submittals. Where conflicts are found during or after the shop drawing submittal process, but before installation of the devices and equipment, the contractor shall notify the engineer of the conflict, and shall adjust the locations of the devices and equipment, where directed by the engineer to do so. The contractor's bid price shall include adjusting the locations of devices and equipment up to 12 feet from the locations on the plan drawings, unless otherwise noted.

Q. Provide a 120VAC Surge Protective Device (SPD) at each equipment that requires 120VAC power, including, but not limited to, each Fire Alarm Control Panel, each Remote Booster Power Supply, each NAC (Notification Appliance Circuit) Panel, each Audio Amplifier Panel, etc. Provide a dedicated SPD for each equipment, whether or not the SPD is indicated in the drawings. Provide junction boxes, wiring, and conduit as required to connect the SPD to the equipment. The SPD shall be located adjacent to the equipment. All work shall comply with the manufacturer's recommendations and NEC requirements.

R. Where the fire alarm system uses speakers for audio notification, provide a microphone with cabinet adjacent to the fire alarm control panel, and the remote annunciator panel and/or graphic annunciator panel at the main entrance. The microphone at the main entrance shall be integrated into a local operating console, that allows paging to be performed. The microphone and associated cabinet shall be provided whether or not these items are indicated in the drawings.

S. A UL listed protective cover (manufactured by Safety Technology International, Inc), with horn and battery, shall be provided for all fire alarm manual pull stations which are located in corridors, vestibules, stairways, lobbies, and other areas which are accessible to the public. Cover shall be furnished and installed in accordance with the manufacturer's recommendations and the applicable codes.

T. All fire alarm wiring shall be installed in raceway, unless otherwise noted and except as follows:
   1. Fire Alarm Metal Clad Cable may be used in lieu of fire alarm wiring in raceway where ALL of the following conditions are met:
      a. Metal Clad Cable is used only in dry locations.
      b. Metal Clad Cable is used only in aboveground applications.
      c. Metal Clad Cable is not subject to physical damage.
      d. Metal Clad Cable is used only in concealed ceilings, walls, and partitions.
      e. Metal Clad Cable is installed only where allowed by the National Electrical Code, NFPA Codes, and Federal/State/Local Codes.

U. Provide the following equipment at the main entrance:
   1. Fire Alarm Graphic Annunciator Panel. The panel shall be 18" wide x 24" high, unless otherwise noted and except as follows:

a. Where the amount of graphics/information that needs to be displayed requires a larger panel, provide a larger panel, but coordinate installation in the field to ensure that everything fits.

2. Fire Alarm Voice Microphone Panel. The panel shall be 18" wide x 14" high, unless otherwise noted, and except as follows:
   a. Where a larger panel is required, provide a larger panel, but coordinate installation in the field to ensure that everything fits.
3. Fire Alarm LCD Annunciator Panel. The panel shall be 9" wide x 6" high, unless otherwise noted, and except as follow:
   a. Where a larger panel is required, provide a larger panel, but coordinate installation in the field to ensure that everything fits.
4. The panels shall be arranged as follows from left to right: Graphic Annunciator Panel, LCD Annunciator Panel, and Voice Microphone Panel. The top of all the panels shall be set at 6' AFF.
5. Where the panels are being installed on a new wall, the panels shall be recessed into the wall. Provide recessed backboxes as required and coordinate depth of the panels with the depth of the new wall.

3.2 CONNECTIONS

A. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

3.3 SEQUENCING AND SCHEDULING

A. Where new fire alarm equipment is being installed in an existing building, maintain the existing fire alarm equipment, which is indicated to be removed in the contract documents, fully operational until the new fire alarm equipment has been tested and accepted. As new fire alarm equipment is installed, label it "NOT IN SERVICE" until it is tested and accepted. Remove labels from new fire alarm equipment when put into service, and label existing fire alarm equipment, which is indicated to be removed in the contract documents, "NOT IN SERVICE" until removed from the building.

B. Where new fire alarm equipment is being installed in an existing building, the existing fire alarm equipment which is indicated to be removed in the contract documents, shall only be removed after the new fire alarm equipment has been tested and accepted by the authorities having jurisdiction.

C. The contractor shall provide temporary equipment as required to keep the existing fire alarm system fully operational while the new fire alarm equipment are being installed, tested, and accepted.

3.4 IDENTIFICATION

A. Each equipment shall be labeled with an address/identification name/number which matches information provided in the submittals or indicated in the drawings. Identify each cable segment between equipment with a unique number corresponding to the address/identification name/number of the associated equipment. Provide a cable schedule which identifies each cable segment and the associated equipment.

B. Install framed instructions in a location visible from fire-alarm control unit.

C. Junction box covers shall be painted red.

D. Fire alarms cables shall be red in color.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by the authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
7. Using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4, field verify that the measured sound level (during a fire alarm condition) in each room, space or area complies ADA and NFPA 72 requirements. Record the measured sound level in each room, space or area, and indicate if it complies with ADA and NFPA 72 requirements. If it does not comply, provide written recommendations in order to fix the deficiency.

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

F. Prepare test and inspection reports.

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

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

3.6 STARTUP SERVICE

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

3.7 SOFTWARE SERVICE AGREEMENT

A. Provide software technical support as follows:
   1. Beginning at Substantial Completion, service agreement shall include software support for two (2) years.
   2. Technical support shall include the following:
      a. Toll free technical support via phone
      b. Technical support via the internet

B. Provide software upgrade service as follows:
   1. At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   2. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION

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

B. The System Supplier shall schedule and present a minimum of 8 hours of documented formalized instruction for the building owner, detailing the proper operation of the installed System.

C. The instruction shall be presented in an organized and professional manner by a person factory trained in the operation and maintenance of the equipment and who is also thoroughly familiar with the installation.

D. The instruction shall cover the schedule of maintenance required by NFPA 72 and any additional maintenance recommended by the system manufacturer.

E. Instruction shall be made available to the Local Municipal Fire Department if requested by the Local Authority Having Jurisdiction.

END OF SECTION

SECTION 31 10 00 - SITE CLEARING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. This Section includes the following:

1. Protection of existing trees indicated to remain.
2. Removal of trees and other vegetation.
3. Topsoil stripping.
4. Clearing and grubbing.
5. Removal and disposal of pavement areas and bituminous speed bumps inclusive of pavement base courses, sidewalk, curb, and combination curb and gutter.
6. Removal of above-grade improvements pertains to those shown on the drawings and all those existing improvements readily visible at the site and in the drawings which interfere with the work.
7. Removing below-grade improvements pertains to those items shown on the drawings, and those associated with the above grade improvements to be removed, if they impede the proposed work.
8. Removal and/or abandonment of utilities and appurtenances.

1.3 DEFINITIONS

A. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

B. Critical Root Zone: As a distance of three feet equal distance from the truck, for each inch of trunk diameter.

1.4 PROJECT CONDITIONS

A. Traffic: Conduct site-clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction. The Contactor shall provide Maintenance of Traffic (MOT) in accordance with the requirements of the Engineer.

B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.

1. Protect improvement on adjoining properties and on Engineer's property.

2. Restore damaged improvements to their original condition, as acceptable to Engineer, in a timely manner and at no additional cost to the Engineer.

C. Soil Erosion and Sediment Control: Soil erosion and sediment control measures are required for this site in accordance with the approved plans. Soil erosion and sediment control measures disturbed or damaged by clearing operations shall be restored to operating condition in accordance with the requirements of the approved plan before the end of the work day for approval by the Engineer.

D. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bar, smothering of trees by stockpiling construction materials or excavated materials within drip line all to be approved by the Engineer, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary tree protection fencing to protect trees and vegetation to be left standing as per plan and approved by the Engineer.

1. Water trees and other vegetation to remain within limits of contract work as required to maintain their health during course of construction operations.

2. Provide protection for roots over 1-1/2 inch in diameter that are cut during construction operations. Coat cut faces with emulsified asphalt or other acceptable coating formulated to use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible. Contractor to schedule a meeting the next day to review installed root protection for approval by the Engineer.

3. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations in manner acceptable to Engineer. Employ a licensed arborist to repair damage to trees and shrubs with prior approval by the Engineer.

4. Replace trees that cannot be replaced and restored to full-growth status, as determined by the Engineer.

5. Prohibit heat sources, flames, ignition sources and smoking within or near tree protection zones.

E. Improvements on Adjoining Property: Authority for performing removal and alteration work on property adjoining Owner's property will be obtained by Owner prior to award of contract.

1. Extent of work on adjacent property is indicated on Drawings.

F. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Engineer's premises where indicated or directed. Refer to Division 01 Section "Construction Waste Management and Disposal."

1.5 EXISTING SERVICES

A. General: Indicated locations are approximate, determine exact locations before commencing Work.

B. Arrange and pay for disconnecting, removing, capping, and plugging, utility services. Notify affected utility companies in advance and obtain approval before starting this Work.

C. Place markers to indicated location of disconnected services. Identify service lines and capping locations on Project Record Documents.

1.6 QUALITY ASSURANCE

A. Comply with standards of authorities having jurisdiction.

B. In the event of a discrepancy between the Project Specifications, Construction Documents, Baltimore City Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction, the more stringent will apply.

PART 2 PRODUCTS -- NOT APPLICABLE

PART 3 EXECUTION

3.1 SITE CLEARING

A. The contractor shall prepare and submit a demolition/construction staging plan to Engineer for approval prior to beginning any construction. Refer to Division 01 Section "Construction Waste Management and Disposal."

B. General: Remove trees, shrubs, grass, and other vegetation, improvements, or obstructions, as required, to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. Removal includes digging out and off-site disposal of stumps and roots.

1. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.

C. Topsoil: Topsoil is defined as friable clay loam surface soil found in a depth of not less than 4 inches. Satisfactory topsoil is reasonably free of subsoil, clay lumps, stones, and other objects over 1/2 inches in diameter, and without weeds, roots, and other objectionable material.

1. Strip topsoil to whatever depths encountered in a manner to prevent intermingling with underlying subsoil or other objectionable material. Remove heavy growths of grass from areas before stripping.
   a. Where existing trees are indicated to remain, leave existing topsoil in place within drip lines to prevent damage to root system.
   b. Precut roots of trees to remain prior to excavating soil near tree saves on site or existing trees offsite.

2. Stockpile topsoil in storage piles in areas indicated or directed. Construct storage piles to provide free drainage of surface water. Cover storage piles, if required, to prevent wind erosion.

3. The thick organic plow layers that are to be stripped generally consist of sandy soils and are expect to be suitable for reuse in the athletic field areas.

4. Dispose of unsuitable or excess topsoil as specified in Section 312000 - Earth Moving for disposal of waste material.

D. Clearing and Grubbing: Clear site of trees, shrubs, and other vegetation, except for those indicated to be left standing.

1. Completely remove stumps, roots, and other debris protruding through ground surface.

2. Use only hand methods for grubbing inside drip line of trees indicated to remain.

3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
   a. Place fill material in horizontal layers not exceeding 8 inches loose depth, and thoroughly compact each layer to a density not less than 90 percent of the maximum dry density when tested in accordance with ASTM D-1557.

E. Removal of Improvements: Remove existing above-grade and below-grade improvements as indicated and as necessary to facilitate new construction.

1. Removal of pavement, including base courses, speed bumps on road, sidewalk, curb, and combination curb and gutter, shall be for the full depth thereof.

2. Existing foundations shall be removed in their entirety.

3. The Contractor shall use suitable equipment, tools, and methods for cutting and trimming as well as removing the materials to the neat lines set by the Engineer and shall not in any manner disturb or damage the sections of base or pavement to be salvaged.

4. Damage done by the Contractor's equipment or methods to those areas designated for salvaging shall be replaced at the Contractor's expense.

5. Where the old subgrade is satisfactory as to condition and elevation, special care shall be taken in the removal operation in order to avoid the disturbing of the old grade.

6. Abandonment or removal of certain underground pipe or conduits may be indicated on mechanical or electrical drawings and is included under work of

related Section 02 41 13. Removing abandoned underground piping or conduits interfering with construction shall be as follows:

a. Underground improvements shall be completely removed to a depth of two feet below indicated subgrade under structures and paving or finished grade in other areas or where it conflicts with proposed construction.

b. Pipes and other utilities indicated to be abandoned in place shall have open ends plugged with concrete for a minimum length of one foot. Structures, manholes, and other utility appurtenances shall be filled with compacted subgrade materials.

7. Fill depressions caused by clearing and grubbing and removal of improvements with satisfactory material, unless further excavation or earthwork is indicated.

3.2 DISPOSITION OF UTILITIES

A. Verify with the Authority having jurisdiction that utility lines indicated to be removed or abandoned are no longer in service before beginning removal or abandonment.

B. Relocation of Utilities: Where utility services (which include water, sewer, storm drains, electrical, gas, telephone, etc.) Are to be relocated as a part of the work of this contract, the Contractor shall maintain the existing utility services in service until the relocate services have been completed and approved. The Contractor shall coordinate with the Authority having jurisdiction to make temporary service connections, re-route services and make tie-ins all as may be required.

C. Unknown Utilities: Where utilities are encountered in the work, the presence of which is not shown or indicated on the drawings, the Contractor shall immediately notify the Authority having jurisdiction. The Contractor shall immediately notify the Authority having jurisdiction and maintain these unknown utility services until instructed by the Authority having jurisdiction as to the proper disposition of the utility.

3.3 DISPOSAL OF WASTE MATERIALS

A. Burning on Engineer's Property: Burning is not permitted on Engineer's property.

B. Removal from Engineer's Property: Remove waste materials and unsuitable or excess topsoil from Engineer's property and dispose of off-site in accordance with local regulations.

3.4 RECORD DRAWINGS

A. Survey and include on record drawings location and depth of all utilities encountered which have not been removed.

END OF SECTION

SECTION 31 23 00 - EXCAVATING, FILLING, AND GRADING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 DESCRIPTION SUMMARY

A. This Section includes the following:

1. Backfilling operation to bring the existing site to grade.
2. Preparing and grading sub grades to slabs-on-grade, walks, pavements, turf and grass, and exterior plants (landscaping).
3. Excavating and backfilling for buildings and structures.
4. Drainage and moisture-control fill course for slabs-on-grade.
5. Subbase course for walks and pavements.
6. Subsurface drainage backfill for walls and trenches.
7. Excavating and backfilling trenches within building lines.
8. Excavating and backfilling for underground utilities and appurtenances.
9. Excavating and backfilling contaminated soils as outlined in the attached "Soil Management Plan."

B. Related Sections:

1. Section 01500: Temporary Utilities
2. Section 311000: Site Clearing
3. Section 329000: Planting

4. Section 033300: Cast-in-Place Concrete

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation:

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.

2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and surface pavement in a paving system.

C. Bedding course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe

D. Borrow Soil: Satisfactory soil material imported from off-site when sufficient approved soil material is not available from on-site excavations.

E. Drainage Fill: Course of washed granular material supporting slab-on-grade placed to cut off upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevation and to lines and dimensions indicated, and the reuse or disposal of materials removed.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Engineer. Authorized additional excavation and replacement will be paid for according to the Contract provisions for changes in Work.

2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.

3. Unauthorized Excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the Engineer. Unauthorized excavation, as well as remedial work directed by the Engineer shall be at the Contractor's expense.

4. Additional excavation: When excavation has reached required subgrade elevations, the contractor will notify the independent testing agency who will make an inspection of conditions and submit inspection report for review and approval the Engineer (authority having jurisdiction). The Contractor is responsible to attain the testing agency and coordinate the scheduling of the inspections such that there is no delay in the Project. If the Inspection Agency determines that bearing material at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by them

5. An independent agency, acceptable to Authorities having Jurisdiction.

G. Fill: Soil materials used to raise existing grades.

H. Recycled Material: Recycled Material shall contain a minimum of 90% post-consumer material.

I. Rock Excavation in Trench Excavation and Pits, including continuous wall footings and individual column footings, shall consist of:

1. The removal of/and disposal of solid rock, ledge rock, rock hard cementitious materials and/or boulders □ cubic yards or more in volume in trench excavations less than 10 feet in width and pits less than 30 feet in either length or width.

2. Excavation of materials that required the use of:
   a. Excavating equipment which exceeds standard Earth Excavating Equipment as defined herein.
   b. Systematic drilling.
   c. Hand-held or backhoe mounted pneumatic hammers
   d. Blasting.

3. Blasting will only be permitted after receiving permission from the Engineer and local authorities. The Contractor shall obtain special liability insurance to protect all parties, including the Engineer from all claims resulting from any blasting.

J. Rock Excavation in open excavation (all excavations other than trench excavation and pit excavation) shall consist of the following:

1. The removal and disposal of solid rock, ledge rock, rock hard cementitious material and/or boulders 2 cubic yards or more in volume.

2. Excavation of materials that requires the use of:
   a. Excavation equipment which exceeds standard Earth Excavation Equipment as defined herein.
   b. Systematic drilling.
   c. Hand-held or backhoe mounted pneumatic hammers.
   3. Blasting will not be permitted.

K. The Contractor is advised that minimum standard earth excavation equipment is defined as follows:

1. For Trench Excavation as defined herein: 250 H.P., track mounted, hydraulic excavator with a 3-foot rock bucket.

2. For Open Excavation as defined herein: 280 H.P. crawler dozer with a single shank ripper.

L. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

M. Subbase Course: The layer between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk

N. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

O. Utilities include on-site underground pipes, conduits, ducts, and cable, as well as underground services within building lines.

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for the following:

1. Each type of warning tape.
2. Filter fabric and geotextiles.
3. Recycled materials.
4. Requirements for local material source.

C. Test Reports: In addition to test reports required under field quality control, submit the following:

1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources, including classification per ASTM D2487.
2. One moisture density curve for each soil material, per AASHTO T-180.
3. Reports of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.
4. All support of excavation submittals must be accompanied by working drawings and design calculations. The drawings and calculations must be signed and sealed by a professional engineer licensed in the State of Maryland.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Perform earthwork complying with requirements of Authorities having Jurisdiction.

B. Testing and Inspection Service: The Contractor will employ a qualified independent geotechnical engineering testing agency to classify proposed on-site and borrow soils to verify that soils comply with specified requirements and to perform required field and laboratory testing during earthwork operations and to check bearing capacities of excavated footings to confirm required bearing capacity prior to installation of reinforcing steel and concrete. All testing and reports shall be provided at no additional cost to the Engineer.

C. Pre-excavation Conference: Before commencing earthwork, meet with representatives of the governing authorities and the Engineer at Project site. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

1.6 PROJECT CONDITIONS

A. Backfilling below-grade areas: The backfilling operation required to bring actual grades to the grade elevations shown on the drawings as existing grades.

1. The borrow material shall be removed and then either stored or disposed. If the testing agency verifies that the borrow material complies with these specifications for backfill material, then the Contractor may use it to backfill this area to grade.

2. Any additional backfill material necessary to complete this operation shall comply with these specifications.

3. This backfilling operation shall be the first earthwork operation performed on site after establishment of the sediment control devices.

B. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. The Engineer, or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.

1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.

C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Engineer and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.

1. Provide a minimum 48-hours-notice to the Engineer and receive written notice to proceed before interrupting any utility.

D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shutoff services if lines are active.

E. Should uncharted or incorrectly charted, piping or other utilities be encountered during excavation, consult Utility Engineer immediately for directions. Cooperate with Engineer and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of Utility Engineer.

F. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Open excavation within the roadways shall be plated and shall be posted with warning devices in accordance with the Manual of Uniform Traffic Control Devices.

1. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dry out to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

2. Work which affects the public right-of-way shall be in accordance with the Baltimore City requirements and regulations.

G. Moisture Sensitive Soils:

1. The on-site founding materials are moisture sensitive and will be easily disturbed by excessive construction activity.

2. The exposed founding materials shall be protected against detrimental changes in engineering qualities as a result of disturbance from rain or frost.

3. Surface runoff shall be drained away from the excavations and not allowed to pond.

4. If possible, concrete shall be placed in the footings the same day the excavations are made, or the founding materials may be covered by mud mats in order to protect the founding soil from becoming saturated due to forecasted precipitation and/or disturbed due to excessive construction activity during the placement of steel reinforcement.

5. The presence of moisture sensitive fine-grained soils poses the potential for high moisture content. Soils may be found to be at or near their plastic limit; consequently, the on-site soils may require discing, aeration, and/or manipulation to achieve efficient compaction.

6. Any regions exhibiting poor drainage characteristics, and low lying areas, shall be expected to display moisture contents which are excessively high for normal earthwork operations.

7. Any standing water shall be drained or pumped into approved sediment control facilities prior to commencement of earthwork.

8. Excavations near to subgrade and all fills should be protected from traffic of heavy equipment, including heavy compaction equipment, when on-site soils exhibit high moisture contents, in order to minimize pumping and a generalized deterioration of these materials.

H. The Contractor is solely responsible for the protection of the sub-grade until it receives final surface treatment and shall maintain the sub-grade as suitable and acceptable to the Engineer. He shall be completely responsible for restoration or replacement of the sub-grade due to moisture damage, construction traffic, or any other cause. Repair or replacement of the sub-grade shall be performed at no additional cost to the Engineer.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations. Classification of materials shall be made by the Engineers independent testing agency.

1. Provide subbase and backfill manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

B. Satisfactory Soil Materials: ASTM D 2487 soil classified as SM , SC, SP, GM, GC, and GP and having a liquid limit less than 35 and a plasticity index less than 20; free of rock or gravel larger than 4 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. However, materials used as backfill behind below-grade walls or retaining walls should have classifications of Sandy SILT (ML), or more granular, in accordance with ASTM D 2487, and should have at least 30 percent by weight of soil particles retained on the No. 200 sieve. Based on the boring results, the majority of the on-site material may be usable as structural fill, provided that its moisture content is within +/-2 percent of the optimum moisture content.

C. Unsatisfactory Soil Materials: ASTM D 2487 soil classification groups CL, MH, CH, OL, OH, and PT.

D. Backfill and Fill Materials: Satisfactory soil materials.

E. Subbase and Base Material: naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand, ASTM D 2940. Graded aggregate for subbase courses shall meet the requirements for G A S/B as shown in Table 312300-1. Recycled concrete (RC-6) should not be used under the building and stormwater management facilities, but may be used for the parking lot.

Table 312300-1

SIEVES		MASS PERCENT PASSING	
Mm	Standard	BRG S/B	G A S/B
100	4 in.		
90	3.5 in.		
63	2.5 in.	100	
50	2 in.		100, ± 3
37.5	1.5 in.		90 - 100, ± 5
25	1 in.	90 - 100	
19	¾ in.		
12.5	½ in.	60 - 100	
9.5	3/8 in.		
4.75	#4		30 - 60, ± 10
2.36	#8		
2.0	#10	35 - 90	
0.60	#30		
0.425	#40	20 - 55	
0.075	#200	5 - 25	0 - 12, ± 5

F. Engineered Fill: Subbase or base materials

G. Bank Run Gravel for subbases: Bank Run Gravel for subbase courses shall meet the requirements for BRG S/B as shown in Table 312300-1.

H. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, AASHTO M43, coarse aggregate grading size 57, with 100 percent passing a 1 inch sieve and not more than 5 percent passing a No. 8 sieve.

I. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone and natural sand, with 100 percent passing a 1inch sieve and 0 to 5 percent passing a No. 50 sieve.

J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

K. Recycled Content of Backfill: Provide recycled concrete (RC-6) for temporary roads, subbase, pipe bedding, and fill material, except under the building slab. Recycled aggregates shall contain a minimum of 90% post-consumer aggregate content.

L. Regional Materials: Provide aggregate and sand products manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

2.2 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep.

1. Tape Colors: Provide tape colors to utilities as follows:
   a. Red — Electric
   b. Yellow: — Gas, oil, steam, and dangerous materials
   c. Orange: — Telephone and other communications
   d. Blue: — Water Systems
   e. Green: — Sewer Systems

B. Filter Fabric: Manufacturer's standard nonwoven previous geotextile fabric of polypropylene, nylon, or polyester fibers, or a combination.

1. Provide filter fabrics that meet or exceed the listed minimum physical properties determined according to ASTM D4759 and the referenced standard test method in parentheses:
   a. Grab Tensile Strength (ASTM D 4362): 100lb.
   b. Apparent Opening Size (ASTM D 4751): #100 U.S. Standard sieve.
   c. Permeability (ASTM 4491): 150 gallons per minute per sq. ft.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, low-density, flowable concrete material produced from the following:

1. Portland Cement: ASTM C 150, Type I Type II or Type III.

2. Fly Ash: ASTM C 618, Class C or F.

3. Normal-Weight Aggregate: ASTM C 33, 3/8-inch nominal maximum aggregate size.

4. Foaming Agent: ASTM C 869.

5. Water: ASTM C 94.

6. Air-Entraining Admixture: ASTM C 260.

PART 3 EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

C. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

D. Tree protection is specified in the Division 31 Section 311000 - "Site Clearing."

3.2 DEWATERING

A. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding project site and surrounding area.

B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

C. All pumped water shall be disposed of as approved by the Engineer and comply with local codes, ordinances and authority having jurisdiction. Provide and maintain pumps, well points, and sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

D. Provide adequate pumps, well points, and other equipment, appurtenances, power, drains, material, and labor necessary to do all pumping needed to keep the excavations, pits, trenches, and all spaces included in the area of the swimming pool and building dry during the casting of mats, footings, slabs, and walls, and at such other times as the progress of the work may demand.

E. During excavation and placing of mats, footings, slabs, and walls, ground water shall be maintained a minimum of one foot below the levels of their bottoms. The dewatering system shall maintain such levels until the backfilling is completed and the removal of the dewatering equipment will not cause or endanger any construction, as determined by the Engineer.

F. The dewatering system shall also be adequate to remove storm water from the excavations and prevent accumulation of surface water within the construction area.

3.3 BACKFILLING BELOW-GRADE AREAS

A. Completely fill below-grade areas and void resulting from the demolition of the site improvements and pavements with compacted fill, as described below, to the grades as shown as existing grades on the drawings.

1. Use satisfactory soil materials, as defined by ASTM D 2487, consisting of SM , SC, SP, GM, GC, and GP having a liquid limit less than 35 and a plasticity index less than 20; free of rock or gravel large than 4 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. However, materials used as backfill behind below-grade walls or retaining walls should have classifications of Sandy SILT (ML), or more granular, in accordance with ASTM D 2487, and should have at least 30 percent by weight of soil particles retained on the No. 200 sieve.

2. Prior to placement of compacted structural fill, the fill subgrade should be stripped of organic layers and then proof rolled under the observation of the Engineers Testing Agency. A minimum 20-ton dump truck should be used for proof rolling. Areas of subgrade that exhibit pumping or contain organic material should be removed down to firm, natural soils. Any additional loose or unsuitable soils found should be removed and replaced with compacted fill.

3. Place fill materials in horizontal layers not exceeding 8 inches in loose depth. Compact each layer to a density not less than 95% of the maximum dry density when tested in accordance with ASTM D-1557, Modified Proctor. In building and pavement areas, the top 12 inches of fill should be compacted to 95% of the maximum density when tested in accordance with ASTM D-1557, Modified Proctor. Fill materials should be placed at moisture contents within +2 points of the optimum moisture content. No compacted fill shall be placed unless a soils technician is present to monitor fill compaction.

B. Testing Agency shall verify compliance of borrow material at both the in-situ location and after the material has been brought to the site.

3.4 EXCAVATION

A. Explosives: Do not use explosives.

B. Unclassified Excavation: Excavation is unclassified and includes excavation to required subgrade elevations regardless of the character of materials and obstructions encountered.

3.5 STABILITY OF EXCAVATIONS

A. Comply with local codes, ordinances, and requirements of authorities having jurisdiction to maintain stable excavations.

B. Slope sides of excavation to comply with local codes, ordinances, and requirements of authorities having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

C. Shoring and bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces in good serviceable condition. Maintain shoring and

bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

3.6 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within tolerance of plus or minus □ inches. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspection.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Appurtenances: Excavate to elevations and dimensions indicated within a tolerance of plus or minus □ inches. Do not disturb bottom of excavations intended for bearing surface.

3.7 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated cross sections, elevation and grades.

3.8 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels, of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.

1. For pipes or conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.

2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bells of loads and ensure continuous bearing of pipe barrel on bearing surface.

3.9 UNAUTHORIZED EXCAVATION

A. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without

altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Engineer.

B. In locations other than those above, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by the Engineer.

3.10 APPROVAL OF SUBGRADE

A. Notify Engineer when excavations have reached required subgrade.

B. When Engineer determines that unforeseen unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

1. Unforeseen additional excavation and replacement material will be paid according to the Contract provisions for changes in Work.

C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Engineer.

3.11 STORAGE OF SOIL MATERIALS

A. Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 BACKFILL

A. Backfill excavations promptly, but not before completing the following:

1. Acceptance of construction below finish grade including, where applicable, damp-proofing, waterproofing, and perimeter insulation.

2. Surveying locations of underground utilities for record documents.

3. Testing, inspecting, and approval of underground utilities.

4. Concrete formwork removal.

5. Removal of trash and debris from excavation.

6. Removal of temporary shoring and bracing, and sheeting.

7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.13 UTILITY TRENCH BACKFILL

A. Place and compact bedding course on unyielding bearing surface and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Concrete backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings. Place concrete to level of 4 inches above bottom of footings.

C. Provide 4 inch thick concrete base slab support for piping or conduit less than 30 inches below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum 4 inches of concrete before backfilling or placing roadway subbase.

D. Place and compact initial backfill of satisfactory soil material or subbase material, free of particles large than 1 inch, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact material under pipe haunches and bring backfill evenly up to both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

E. Coordinate backfilling with utilities testing.

F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.

G. Place and compact final backfill of satisfactory soil material to final subgrade.

H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.14 BUILDING SLAB DRAINAGE COURSE

A. General: Drainage course consists of placement of drainage fill material, in layers of indicated thickness, over subgrade surface to support concrete building slabs.

B. Placing: Place drainage fill material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting material during placement operations.

1. Provide minimum 4 inches of drainage fill below all slabs. Drainage fill shall be an evenly graded mixture of natural or crushed gravel or crushed stone and natural sand with 95-100 percent passing a 1 inch sieve and less than 12 percent passing a No. 200 sieve. Place in a single layer and compact to a minimum of 95 percent of the maximum dry density, as determined by the Modified Proctor compaction test method ASTM D 1557. Overlay fill with vapor barrier below all slabs.

3.15 SUBSURFACE DRAINAGE BACKFILL

A. Subsurface Drain: Place a layer of filter fabric around perimeter of drainage trench or at footing, as indicated. Place a 6 inch compacted course of filtering material on filter fabric to support drainage pipe. After installing and testing, encase drainage pipe in a minimum of 6 inches of compacted filtering material and wrap in filter fabric, overlapping edges at least 6 inches.

B. Impervious Fill: Place and compact impervious fill material for top 12" to final subgrade.

3.16 FILL

A. Preparation: Remove vegetation, topsoil, debris, wet, and unsatisfactory soil materials, obstruction, and deleterious materials from ground surface prior to placing fills.

1. Plow strip, or break up sloped surface steeper than 1 vertical 4 horizontal so fill material will bond with existing surface. Compact all surfaces with a minimum 10-ton smooth drum or sheepfoot roller.

B. When subgrade or existing ground surface to receive fill has density less than required for fill, break up ground surface to depth required, pulverize, moisture-condition or aerate soil and re-compact to required density.

C. Place fill material in layers to required elevations for each location listed below.

1. Under grass, use satisfactory excavated or borrow soil material.

2. Under walks, pavements, and footings use subbase or base material, or satisfactory excavated or borrow soil material.

3. Under steps and ramps, use subbase material.

4. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.

3.17 MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 3 percent of optimum moisture content.

1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air-dry satisfactory soil material that is too wet to compact to specified density.
   a. Stockpile or spread and dry removed wet satisfactory soil material.

3.18 COMPACTION

A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill materials evenly on all sides of structures to required elevations to prevent wedging action. Place backfill and fill uniformly along the full length of each structure.

C. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Engineer if soil density tests indicate inadequate compaction.

D. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density according to ASTM D-1557 (Modified Proctor):

1. Under structures, building slabs, steps, compact the top 12 inches of fill materials below subgrade to 95 percent maximum density. Each layer of backfill or fill material below the top 12 inches should be compacted to 90 percent maximum dry density.

2. Under pavement, compact the top 12 inches of fill materials below subgrade to 95 percent maximum density. Each layer of backfill or fill material below the top 12 inches should be compacted to 90 percent maximum dry density.

3. Under walkways, compact the top 6 inches below subgrade and each layer of backfill or fill material at 90 percent maximum density.

4. Under lawn or unpaved areas, compact the top 6 inches below subgrade and each layer of backfill or fill material at 85 percent maximum density.

E. Proof roll all areas which are to receive pavements and slab-on-grade for the proposed school building with vehicle having a minimum axle load of 20 tons. Unsuitable materials shall be removed and replaced with new compacted fill.

F. When existing ground surface has a density less than that specified under "Compaction" for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content, and compact to required depth and percentage of maximum density.

3.19 GRADING

A. General: Uniformly grade areas to a smooth surface free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between existing adjacent grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.

2. Walks: Plus or minus 1 inch.

3. Pavements: Plus or minus 1/2 inch.

C. Grading Inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.20 SUBBASE AND BASE COURSES

A. Under pavements and walks, place subbase course material on prepared subgrades. Place base course material over subbases to pavements.

1. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of ASTM D 4254 relative density.

2. Shape subbase and base to required crown elevations and cross-slope grades.

3. When thickness of compacted subbase or base course is 6 inches or less, place materials in a single layer.

4. When thickness of compacted subbase or base course exceed 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

B. Pavement Shoulders: Place shoulder along edges of subbase and base course to prevent lateral movement. Construct shoulders at least 12 inches wide of acceptable soil materials and compact simultaneously with each subbase and base layer.

3.21 DRAINAGE FILL

A. Under slabs-on-grade, place drainage fill course on prepared subgrade.

1. Compact drainage fill to required cross sections and thickness,

2. When compacted thickness of drainage fill is 6 inches or less, place materials in a single layer.

3. When compacted thickness of drainage exceeds 6 inches thick place materials in equal layers, with no layer more than 6 inches thick nor less than 3 inches thick when compacted.

3.22 FIELD QUALITY CONTROL

A. Testing Agency Service: Engage qualified independent testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements that shall be reviewed and approved by the Engineer.

1. Perform field-in-place density tests according to ASTM D 1556 (sand cone method).
   a. Field-in-place density tests may also be performed by the nuclear method according to ASTM D 2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. With each density calibration check, check the calibration curves furnished with the moisture gages according to ASTM D 3017.
   b. When field-in-place density tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of work, on each difference type of material encountered, and at intervals as directed by the Engineer.

2. Footing Subgrade: Inspect bearing state at each column footing and at twenty foot intervals in wall footings, at the footing subgrade, to verify required bearing capacity.

3. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, perform at least one field in-place density test for every 2000 sq. ft. or less of paved areas or building slab, but in no case fewer than three tests.

4. Foundation Wall Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 50 feet or less of wall length, but no fewer than two tests along a wall face.

5. Trench Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 50 feet or less of trench, but no fewer than two tests.

B. When qualified independent testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained. Testing will be paid by the Contractor at no additional cost to the Engineer.

3.23 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace material to depth directed by the Engineer; reshape and re-compact at optimum moisture content to the required density.

C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.24 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Contractor shall remove and dispose of offsite all excess topsoil and/or borrow remaining after final grading has been completed.

1. Remove waste material, including unsatisfactory soil trash, debris, and legally dispose of off the Engineer's property.

END OF SECTION

SECTION 31 23 19 - DEWATERING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. Section includes construction dewatering.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and dewatering system progress.

2. Section 312300 "Excavating, Filling & Grading" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

1.3 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.

3. Review geotechnical report.

4. Review proposed site clearing and excavations.

5. Review existing utilities and subsurface conditions.

6. Review observation and monitoring of dewatering system.

1.4 SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.

2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.

3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.

4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

B. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in Maryland responsible for their preparation.

C. Qualification Data: For Installer and professional engineer.

D. Field quality-control reports.

E. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

F. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of the Engineer.

1.6 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project. Contractor may employ a geotechnical engineer as necessary, to be approved by the Engineer, to render opinions and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Engineer is not responsible for interpretations or conclusions drawn from this data. Geotechnical report will be paid for by the Contractor at no additional cost to the Engineer.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations. Survey work will be paid for by the Contractor at no additional cost to the Engineer.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.

2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.

3. Prevent surface water from entering excavations by grading, dikes, or other means.

4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.

5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

PART 3 EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.

2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Engineer and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Protect and maintain temporary erosion and sedimentation controls, which are specified on the MDE approved plans.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.

2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

3. Maintain piezometric water level a minimum of 24 inches below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction. These procedures described will be paid for by the Contractor at no additional cost to the Engineer.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.

2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.

3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Engineer if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

D. Prepare reports of observations.

3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION

SECTION 31 25 00 - SOIL EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

D. Sediment and Stormwater Administration Maryland Department of the Environment, 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control, dated December 2011, and addendum thereto.

1.2 SUMMARY

A. The extent of soil erosion and sediment control facilities is shown on the Erosion and Sediment Control Plans, approved by the Baltimore City Soil Conservation District.

1.3 QUALITY ASSURANCE

A. Comply with local codes where applicable and to the requirements of all permits.

B. Comply with the provisions outlined in Division 1.

1.4 LEED SUBMITTALS

A. SS prerequisite 1, Construction Activity Pollution Prevention: Provide six photos of sedimentation and erosion control measures in place on two separate occasions during construction. 12 photos total are required.

PART 2 PRODUCTS

2.1 MATERIALS REQUIREMENTS

A. Material requirements are specified on the drawings.

PART 3 EXECUTION

3.1 GENERAL

A. Installation of the soil erosion and sediment control facilities shall be as shown and specified on the Sediment/Erosion Control Plans and Detail sheets of the Contract Drawings.

3.2 TIMING

A. All perimeter control shall be installed and approved by the Sediment Control Inspector as specified in the "Sequence of Construction" on the Contract Drawings.

3.3 MAINTENANCE

A. All soil erosion and sediment control measures shall be maintained continuously during the construction period.

B. Soil erosion and sediment control measures shall be inspected daily, and any measure which has been disturbed or damaged shall be repaired and restored to operating condition in accordance with the approved plan before the end of each work day.

3.4 REMOVAL

A. Soil erosion and sediment control measures shall not be removed until the removal has been authorized by the Sediment Control Inspector.

END OF SECTION

SECTION 31 31 16 – TERMITE CONTROL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. This Section includes soil treatment for termite control.

1.3 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.

B. Product data and application instructions.

C. Certification that products used comply with US Environmental Protection Agency (EPA) regulations for termiticides.

1.4 QUALITY ASSURANCE

A. In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for preparing substrate and application.

B. Engage a professional pest control operator who is licensed according to regulations of governing authorities to apply soil treatment solution.

C. Use only termiticides that bear a federal registration number of the EPA and are approved by local authorities having jurisdiction.

D. In the event of a discrepancy between the Project Specifications, Construction Documents, Baltimore City Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.

1.5 JOB CONDITIONS

A. Restrictions

1. Do not apply soil treatment solution until excavating, filling, and grading operations are completed, except as otherwise required in construction operation.

2. To ensure penetration, do not apply soil treatment to frozen or excessively wet soils or during inclement weather.

3. Comply with handling and application instructions of the soil toxicant manufacturer.

1.6 WARRANTY

A. Warranty: Furnish written warranty, executed by Applicator and Contractor, certifying that applied soil termiticide treatment will prevent infestation of subterranean termites.

1. If subterranean termite activity if discovered during warranty period, Contractor will re-treat soil and repair or replace damage caused by termite infestation.

2. The warranty shall not deprive the Engineer of other rights the Engineer may have under other provisions of the Contract Documents and will be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

B. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 SOIL TREATMENT SOLUTION

A. General: Use an emulsible, concentrated termiticide that dilutes with water, specially formulated to prevent termites infestation.

1. Fuel oil will not be permitted as a diluent.

2. Provide a solution consisting of one of the following chemical elements.

B. Available Products: Subject to compliance with requirements, products that may be incorporated in the Work include, but are not limited to, the following:

1. Termiticides:
   a. Aventis Environmental Science USA LP; Termidor.
   b. Bayer Corporation; Premise 75.
   c. Dow AgroSciences LLC; Dursban TC.
   d. FMC Corporation, Agricultural Products Group; Talstar, Prevail FT Torpedo.
   e. Syngenta; Demon TC.

C. Dilute with water to concentration level recommended by manufacturer.

D. Other solutions may be used as recommended by Applicator if approved for intended application by local authorities having jurisdiction.

E. Use only soil treatment solutions that are not harmful to plants.

PART 3 EXECUTION

3.1 APPLICATION

A. Surface Preparation: Remove foreign matter that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and foundations. Toxicants may be applied before placing compacted fill under slabs if recommended by toxicant manufacturer.

B. Application shall not take place if rain is forecasted within a 24 hour period.

C. Application Rates: Apply soil treatment solution as follows:

1. Under slab on-grade structures, treat soil before concrete slabs are placed, using the following application rates:
   a. Apply 4 gallons of chemical solution per 10 linear feet to soil in critical areas under slab, including entire perimeter of foundation walls, along both sides of interior partition walls, around plumbing pipes and electric conduit penetrating slab, and around interior column footers.
   b. Apply 1 gallon of chemical solution per 10 sq. ft. as an overall treatment under slab and attached slab areas where fill is soil or unwashed gravel. Apply 12 gallons of chemical solution per 10 sq. ft. to areas where fill is washed gravel or other coarse absorbent material.
   c. Apply 4 gallons of chemical solution per 10 linear feet of trench for each 12 inches of depth from grade to footing, along outside edge of building. Dig a trench 6 to 8 inches wide along outside of foundation to a depth of not less than 12 inches. Punch holes to top of footing at not more than 12 inches o.c. and apply chemical solution. Mix chemical solution with the soil as it is replaced in the trench.

2. At hollow masonry foundation or grade beams, treat voids at a rate of 2 gallons per 10 linear feet poured directly into the hollow spaces.

3. At expansion joints, control joints, and areas where slabs will be penetrated, apply at rate of 4 gallons per 10 linear feet of penetration.

D. Post signs in areas of application to warn workers that soil termiticide treatment has been applied. Remove signs after areas are covered by other construction.

E. Reapply soil treatment solution to areas disturbed by subsequent excavation, landscape grading, or other construction activities following application.

END OF SECTION

SECTION 31 50 00 - EXCAVATION SUPPORT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Requirements of the herein attached, "Soil Management Plan," shall supersede work outlined under this general section.

D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. Section includes temporary excavation support and protection systems.

B. Related Requirements:

1. Section 013233, "Photographic Documentation," for recording preexisting conditions and excavation support and protection system progress.

2. Section 312300, "Excavation, Filling & Grading, " for excavating and backfilling and for controlling surface-water runoff and ponding.

3. Section 312319, "Dewatering," for dewatering excavations.

1.3 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1. Review existing utilities and subsurface conditions.

2. Review coordination for interruption, shutoff, capping, and continuation of utility services.

3. Review proposed excavations.

4. Review proposed equipment.

5. Review monitoring of excavation support and protection system.

6. Review coordination with waterproofing.

7. Review abandonment or removal of excavation support and protection system.

1.4 SUBMITTALS

A. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.

2. Show arrangement, locations, and details of soldier piles, piling, lagging, tiebacks, bracing, and other components of excavation support and protection system according to engineering design.

3. Indicate type and location of waterproofing.

4. Include a written plan for excavation support and protection, including sequence of construction of support and protection coordinated with progress of excavation.

B. Qualification Data: For Installer and Professional Engineer.

C. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

E. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.5 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Engineer or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Engineer and Engineer no fewer than two days in advance of proposed interruption of utility.

2. Do not proceed with interruption of utility without Engineer's written permission.

B. Project-Site Information: A geotechnical report has not been prepared for this Project. Contractor shall employ a geotechnical engineer as necessary, to be approved by the Engineer, to render opinions and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Engineer is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.

2. The geotechnical report is included elsewhere in Project Manual.

C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Geotechnical Testing Agency: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

B. Provide, design, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.

2. Prevent surface water from entering excavations by grading, dikes, or other means.

3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

2.2 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36, ASTM A 690, or ASTM A 992.

C. Steel Sheet Piling: ASTM A 328, ASTM A 572, or ASTM A 690; with continuous interlocks.

1. Corners: Site-fabricated mechanical interlock.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.

E. Tiebacks: Steel bars, ASTM A 722.

PART 3 EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Engineer. Provide alternate routes around closed or obstructed traffic ways if required by Engineer.

C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Engineer.

2. Install internal bracing if required to prevent spreading or distortion of braced frames.

3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Engineer if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.7 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.

2. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."

3. Repair or replace, as approved by Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION

SECTION 32 01 90 - OPERATION AND MAINTENANCE OF PLANTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details (latest edition), and as noted on the Drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. Supply all labor, materials, gasoline, oil, equipment, and supplies to maintain the lawn for the time period as specified in Section 32 90 00.

B. Maintain lawns by watering, fertilizing, weeding, mowing, trimming and other operations such as rolling, regrading and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

1.3 SUBMITTALS

A. Within 14 days of Notice to Proceed the Contractor shall submit a complete list of equipment to be reviewed by the Engineer.

B. Within 14 days of Notice to Proceed, the Contractor shall submit a complete Maintenance Schedule to be reviewed by the Engineer.

1.4 EXISTING CONDITIONS

A. It will be the responsibility of the Contractor to visit the site and be thoroughly familiar with its configuration and dimensions.

PART 2 – PRODUCTS

2.1 EQUIPMENT

A. The Contractor must furnish a list of machinery that he will use for the work above.

1. This equipment will be inspected by the Owner or his authorized representative before the contract is approved in order to determine whether it is adequate.

2. All equipment must meet all OSHA and MOSHA standards and be equipped with turf type tires.

B. The Contractor shall maintain the cutting edge of all mowing equipment in sharp condition and proper adjustment.

1. All mowing equipment shall be maintained in accordance with manufacturers' instructions and shall meet safety requirements specified herein.

2. Equipment guards, shield and mufflers shall be kept intact and capable of performing their intended functions.

2.2 SOURCE QUALITY CONTROL

A. Use of subcontractors is permissible, however, each subcontractor and their equipment shall be approved in advance by the Owner or his authorized representative.

B. The Contractor will be responsible for ensuring that subcontractors comply with the provisions of this contract.

PART 3 - EXECUTION

3.1 PREPARATION

A. Maintenance of lawns shall begin immediately after installation and continue until acceptance of work. Warranty and maintenance period shall begin upon written acceptance of work and continue through the period specified in Section 32 90 00.

B. Apply pre-emergent crabgrass control the following spring between April 1st through 15th and follow that with an application of post emergent crabgrass control in early June as needed or apply post emergent broadleaf weed control as needed between May 15th and June 15th. The contractor must follow all Maryland IPM laws for pesticide application.

B. The Contractor shall notify the Owner by 2:00 p.m. the day before each site will be cut. Contractor will notify the Owner before 7:30 a.m. if he is not able to cut that day.

C. The Contractor shall not mow over debris and is required to pick up trash before mowing.

D. The turf will not be cut below a height of 2½" to 3". Maximum height of turf shall be no higher than 5" at any given time.

E. All finishing work around and in obstacles such as trees, drainage ditches, storm drains, manhole covers, fences, buildings, parking lots, and curb and gutters, including removal of grass and weeds in cracks etc.
1. This work shall be completed during the time the grass is cut.
2. Contractors are required to sweep or blow grass clippings off all walks and curbs.
3. If the Contractor is licensed and insured, Roundup may be used if approved by the Owner and must be applied in accordance with Maryland Department of Agriculture IPM standards for notification and posting of the property.
4. A deduction to contract price will be made if punch list items are not corrected.
5. Contractor will have 3 working days, including Saturday to correct deficiencies after notice has been given.

6. Areas will be re-inspected by the Engineer to determine if work has been satisfactorily corrected.

G. The Contractor must take all precautions necessary to avoid damaging obstacles such as trees, plants, fences, signs, drain covers, sewer clean outs, lights, turf, etc.
1. Any damage caused by the Contractor's improper work will be repaired by the

Contractor to the satisfaction of the Owner.

2. If damages are not repaired within 10 days the Owner will have the damages repaired at the Contractor's expense.

3.2 SAFETY

A. Any barricades or protective equipment required by the Contractor to make the work site safe shall be his responsibility.

3.3 AUTHORIZATION

A. All work shall be inspected by the Architect and Engineer.

END OF SECTION

SECTION 32 13 00 – RIGID PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. This Section includes exterior Portland cement concrete paving for the following:

1. Curbs and gutters.
2. Walkways.
3. Dumpster pad.

B. Related Sections:

1. Section 312300: Excavating and Filling
2. Section 033300: Cast-in-Place Concrete
3. Section 321723: Pavement Marking

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specifications Sections.

B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Engineer.

C. LEED Submittals:

1. Product Data for Credit MR 4: For recycled content materials, documentation indicating percentages of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.

2. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material content.

3. SS credit 7.1, Heat Island Effect, Non Roof: Provide manufacturer's cut sheets for all impervious paving materials, highlighting the Solar Reflectance Index (SRI) of the material.

D. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

E. Laboratory test reports for evaluation of concrete materials and mix design tests.

F. Material certificates in lieu of material laboratory test reports when permitted by Engineer. Material certificate shall be assigned by manufacturer and Contractor certifying that each material item complies with or exceed requirements. Provide certification from admixture manufacturers that chloride content complies with requirements.

1.4 QUALITY ASSURANCE

A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.

1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings."

2. ACI 318, "Building Code Requirements for Reinforced Concrete."

3. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."

B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

C. Concrete Testing Service: The Contractor will engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes at no additional cost to the Engineer.

D. Regional Materials: Provide aggregate products manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

1.5 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other acceptable panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

B. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 fL volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars and Tie Bars: ASTM A 615, Grade 60, deformed.

1. Recycled Content: Provide steel with minimum 90 percent recycled content, 60 percent post-consumer.

2. Regional Materials: Provide steel manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

B. Welded Steel Wire Fabric: ASTM A 185.

1. Furnish in flat sheets, not rolls, unless otherwise acceptable to Engineer.

C. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with end square and free of burrs.

D. Hook Bolts: ASTM A 307, Grade A bolts, internally and externally threaded. Design hook bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

E. Supports for Reinforcement: Chairs, spacers, dowel bar supports, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire fabric, and dowels in place. Use wire bar-type supports complying with CRSI specifications.

1. Use supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type I, white. Supplement with the following:
   a. Fly Ash: ASTM C 618, Class C.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.

2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

3. Regional Materials: Provide aggregate manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

C. Aggregate for Exposed Concrete Pavement: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

1. Aggregate Size: 1/2 inch nominal.

2. Aggregate Shape, and Color: Rounded, earth tone (white, beige, brown) color.

D. Solar Reflectance Index (SRI) of Concrete Paving: Minimum value of 29.

E. Water: Potable.

2.4 ADMIXTURES

A. Provide concrete admixtures that contain no more than 0.1 percent chloride ions.

B. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.

C. Water-Reducing Admixture: ASTM C 494, Type A.

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

1. Air-Entraining Admixture:
   a. Air-Tite or Amex 210; Cormix Construction Chemicals.
   b. Air-Mix or Perma-Air; Euclid Chemical Co.
   c. Darex AEA or Daravair; W.R. Grace & Co.
   d. MB-VR or Micro-Air, Master Builders, Inc.
   e. Sealtight AEA; W.R. Meadows, Inc.
   f. Sika AER; Sika Corp.

2. Water-Reducing Admixture:
   a. Chemtard; ChemMasters Corp.
   b. Type A Services; Cormix Construction Chemicals
   c. Eucon WR-75; Euclid Chemical Co.
   d. WRDA; W.R. Grace & Co.
   e. Pozzolith Normal or Polyheed; Master Builders, Inc.
   f. Metco W.R.; Metalcrete Industries
   g. Plastocrete 161; Sika Corp.

2.5 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

1. Available Products:
   a. Axim Concrete Technologies; Cimfilm.
   b. Burke by Edeco; BurkeFilm.
   c. ChemMasters; Spray-Film.
   d. Conspec Marketing & Manufacturing Co., Inc.; Aquafilm.
   e. Dayton Superior Corporation; Sure Film.
   f. Euclid Chemical Company (The); Eucobar.
   g. Kaufman Products, Inc.; Vapor Aid.
   h. Lambert Corporation; Lambco Skin.
   i. L&M Construction Chemicals, Inc.; E-Con.
   j. MBT Protection and Repair, ChemRex Inc.; Confilm.
   k. Meadows, W. R., Inc.; Sealtight Evapre.
   l. Metalcrete Industries; Waterhold.
   m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
   n. Sika Corporation, Inc.; SikaFilm.
   o. Symons Corporation; Finishing Aid.
   p. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

C. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

1. Available Products:
   a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
   b. Burke by Edoko; Aqua Resin Cure.
   c. ChemMasters; Safe-Cure Clear.
   d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
   e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
   f. Euclid Chemical Company (The); Kurez DR VOX.
   g. Kaufman Products, Inc.; Thinfilm 420.
   h. Lambert Corporation; Aqua Kure-Clear.
   i. L&M Construction Chemicals, Inc.; L&M Cure R.
   j. Meadows, W. R., Inc.; 1100 Clear.
   k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
   l. Symons Corporation; Resi-Chem Clear.
   m. Tamms Industries Inc.; Horncure WB 30.
   n. Unitex; Hydro Cure 309.
   o. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

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

1. Liquid Membrane-Forming Curing Compound:
   a. Clear Cure; Anti-Hydro Co., Inc.
   b. Spartan-Cote; The Burke Co.
   c. All Resin; Conspec Marketing & Mfg. Co.
   d. Sealco 309; Cormix Construction Chemicals
   e. Day-Chem Cure and Seal; Dayton Superior Corp.
   f. Diamond Clear; Euclid Chemical Corp.
   g. #64 Resin Cure-Clear; Lambert Corp.
   h. L&M Cure R; L&M Construction Chemicals
   i. Masterkure; Master Builders, Inc.
   j. 3100 Series; W.R. Meadows, Inc.
   k. Seal N Kure; Metalcare Industries
   l. Kure-N-Seal; Sonneborn-Chemrex
   m. Horn Clear Seal; Tamms/A.C. Horn

2.6 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.7 CONCRETE MIX

A. Prepare design mixes for each type and strength of normal-weight concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use a qualified independent testing agency for preparing and reporting proposed mix designs.

1. Do not use the Engineer's field quality-control testing agency as the independent testing agency.

B. Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight concrete with the following properties:

1. Compressive Strength (28-Day): 3000 psi

2. Maximum Water-Cement Ratio at Point of Placement: 0.45

3. Slump Limit at Point of Placement: 4 inches, plus or minus 1 inch.

C. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture in concrete, as required, for placement and workability.

2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

3. Use water-reducing admixture in pumped concrete, concrete required to be watertight and concrete with a water-cementitious materials ratio below 0.50.

D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals. as follows:

1. Fly Ash or Pozzolan: 25 percent.

2. Ground Granulated Blast-Furnace Slag: 50 percent.

3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

E. Fiber Reinforcement: Add to mix at a rate of 1/5 lb per cu. yd., unless manufacturer recommends otherwise.

F. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, project condition, weather, test results, or other circumstances warrant.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.

1. When air temperature is between 85 deg. F and 90 deg. F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg. F, reduce mixing and delivery time to 60 minutes.

2.9 JOINT MATERIALS

A. Zip strip control joint manufactured by Superior Featherweight Tools, Inc. or approved equal.

B. Performed Joint Fillers

1. The cork type shall be in accordance with AASHTO M153.

2. The bituminous fiber type shall be in accordance with AASHTO M213 with the bituminous content determined by AASHTO T164.

3. The weathering test shall be deleted for either type of material.

C. Roofing paper to be used in construction joints shall be composed of roofing felt saturated and coated on both sides with an asphaltic material. It shall not weight less than 39.8 lbs/square foot and shall not crack when bent over 1/2 inch radius at room temperature.

2.10 JOINT SEALANTS

A. Compatibility: Sealant fillers and all adjacent materials shall be compatible as demonstrated by sealant manufacturer testing.

B. Colors - Provide color of exposed joint sealants to comply with the following:

1. Match colors of concrete.

C. Cold Applied Joint Sealants shall be one part, polyurethane-base sealant for concrete pourable, chemically curing elastomeric formulation complying with the following requirements relative to formulation with ASTM C 920 for Type S, Grade NS, Class 25, and Uses indicated.

2.11 JOINT SEALANT BACKING

A. General: Provide sealant backings of material and type that are non-staining; are compatible with joint substrates; sealants, primers, and other joint fillers, and are approved for applications indicated by sealants manufacturer based on field experience and laboratory testing.

B. Backer Rods for Cold Applied Sealants: Performed, compressible, resilient, non-waxing, non-extruding strips of flexible, plastic foam of material indicated below and of size, shape, and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

1. Closed cell polyethylene foam, nonabsorbent to liquid water and gas, and non-outgassing in un-ruptured state.

2. Proprietary, reticulated, closed-cell polymeric foam, non-outgassing, with a density of 2.5 pcf. and tensile strength of 35 psi per ASTM D 1623, and with water absorption less than 0.02 gram/cubic centimeter per ASTM C 1083.

3. Either material indicated above.

C. Bond Breaker Type: Polyethylene tape of other plastic tape as recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesions would result in sealant failure. Provide self-adhesive tape where applicable.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving.

B. Remove loose material from compacted subbase immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in pace at least 24 hours after concrete placement

B. Check completed formwork and screeds for grade and alignment to following tolerances:

1. Top of Forms: Not more than 1/2 inch in 10 feet.

2. Vertical Face on Longitudinal Axis: Not more than 1/2 inch in 10 feet.

C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.3 PLACING REINFORCEMENT

A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain maximum cover to reinforcement.

D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and laces splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.4 JOINTS

A. General: Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.

B. Contraction joints: Provide weakened-plane contraction joints, sectioning concrete into areas as shown on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, as follows:

1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8 inch wide joints into hardened concrete when cutting action will not tear, abrade, or otherwise damage surface and before development of random contraction cracks.

3. Inserts: Form contraction joints by inserting pre-molded plastic, hardboard, or fiberboard strips into fresh concrete until top surface of strip is flush with paving surface. Radius each joint edge with a jointer tool. Carefully remove strips or caps of two-piece assemblies after concrete has hardened. Clean groove of loose debris.

C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour, unless paving terminates at isolation joints.

1. Provide performed galvanized steel or plastic keyway-section forms or bulkhead forms with key, unless indicated otherwise. Embed keys at least 1-1/2 inches into concrete.

2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.

3. Provide tie bars at sides of paving strips where indicated.

4. Use bonding agent one existing concrete surfaces that will be joined with fresh concrete.

D. Isolation Joints: Form isolation joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 40 feet, unless indicated otherwise.

2. Extend joint filler full width and depth of joint, not less than □ inch or more than 1 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.

3. Furnish joint filler in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.

4. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protection cap after concrete has been placed on both sides of joint.

E. Walks shall be constructed to match existing concrete at existing road tie-ins.

1. Expansion joints between building and pavement shall be cork.

2. Pavements shall be separated from curbs by a construction joint using felt roofing paper material.

3. "Zip Strip" control joint to be installed at a maximum of 24' and between existing walks and new concrete.

4. Saw cut control joints are not permitted.

5. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one half of dowel length to prevent concrete bonding to one side of joint.

3.5 JOINT SEALANT INSTALLATION

A. Clean out joints before installing joint sealants to comply with recommendations of manufacturer.

B. Comply with Joint Manufacturer printing installation instructions and recommendations of ASTM C 962 for use of joint sealants.

C. Immediately after sealant application and prior to time skinning or curing begins, tool sealants to a smooth, uniform bead to eliminate air pockets and to ensure contact and adhesion of sealant with sides of joint.

1. Do not use tooling agent that discolor sealants or adjacent surface or are not approved by the sealant manufacturer.

2. Protect joint sealants during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so they are without deterioration at final acceptance.

3.6 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete framework installation, reinforcing steel, and item to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove ice, snow, or frost from subbase surface and reinforcing before placing concrete. Do not place concrete on surfaces that are frozen.

C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

D. Comply with requirements with ACI 304R for measuring, mixing, transporting, and placing concrete.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

1. When concrete placing is interrupted for more than 1/2 hour, place a construction joint.

F. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidation concrete complying with ACI 309R.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.

H. Screed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.

I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer or use bonding agency if acceptable to Engineer.

J. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutter to required cross section, lines, grade, finish and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.

K. Slip Form Pavers: When automatic machine placement is used for paving, submit revised mix design and laboratory test results that meet or exceed requirements. Produce paving to required thickness, lines, grades, finish, and jointing as required for formed paving.

1. Compact subbase and prepared subgrade of sufficient width to prevent displacement of pave machine during operation.

L. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

M. Cold Weather Placement: Comply with provision of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. Concrete placement shall begin only when the ambient air and surface temperature is at least 40 deg. F and rising and discontinued anytime the temperature falls below 40 deg. F. Placing concrete on a frozen base is prohibited.

2. Do not use frozen materials or materials containing ice or snow.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agent or chemical accelerators unless otherwise accepted in mix designs.

N. Hot Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 70 deg. F. Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to concrete is Contractor's option.

2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperation immediately before embedding in concrete.

3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft sport, or dry areas.

3.7 CONCRETE FINISHING

A. Float Finish: Begin floating when bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across concrete, perpendicular to line of traffic, to provide a uniform gritty texture finish.

2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across concrete surface perpendicular to line of traffic to provide a uniform fine line texture finish.

B. Final Tooling: Tool edges of paving, gutter, curbs, and joints formed in fresh concrete with a jointing tool to the following radius. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.

1. Radius: 3/8 inch

3.8 CONCRETE PROTECTION AND CURING

A. General: Following texturing and edging, the concrete shall be cured for a minimum of 72 hours. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.

B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instruction after screeding and bull floating, but before floating.

C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture-Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and keep continuously wet. Cover concrete surfaces and edges with a 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.9 FIELD QUALITY CONTROL TESTING

A. The Contractor will employ a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement at no additional cost to the Engineer. Test results will be provided for review and approval by the Engineer. Sampling and testing for quality control may include the following:

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
   a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
   b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test but no less than one test for each day's pour of each type of air-entrained concrete.
   c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg. F and below and when 80 deg. F and above, and one test for each set of compressive-strength specimens.

d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.

e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. But less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.

2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.

3. When total quantity of a given class of concrete is less than 50 cu. yd., Engineer may waive strength testing if adequate evidence of satisfactory strength is provided.

4. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operation and provide corrective procedures for protecting and curing the in-place concrete.

5. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test results falls below specified compressive strength by more than 500 psi.

B. Test results will be reported in writing to Engineer, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests. These tests and providing test reports will be paid by the Contractor at no additional cost to the Engineer.

C. Nondestructive Testing: Impact hammer sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.

D. Additional Tests: The testing agency will make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Engineer. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. The testing and providing test reports will be paid by the Contractor at no additional cost to the Engineer.

3.10 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.

B. Drill test cores where directed by Engineer when necessary, to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than 2 days prior to date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 31 19 - DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Decorative steel fences.

B. Pre-hung steel gates.

1.2 SUBMITTALS

A. Product Data: Submit 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.

B. Shop Drawings:

1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.

C. Samples: Submit two samples of fence panels, slat infill, 2 inch by 2 inch in size illustrating construction and colored finish.

D. Manufacturer's Installation Instructions: Indicate installation requirements, post foundation anchor bolt templates, and _____.

E. Manufacturer's Warranty.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

B. Installer Qualifications: Experienced with type of construction involved and materials and techniques specified and approved by fence manufacturer.

C. Provide fence and gate products from the same manufacturer.

1.4 WARRANTY

A. Correct defective Work within a five year period after Date of Substantial Completion.

B. Provide 20 year manufacturer warranty for all structural fence components.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Decorative Metal Fences and Gates:

1. Ameristar Perimeter Security, USA: www.ameristarfence.com/#sle.

2.2 FENCES

A. Fences: The fence system shall conform to Montage II Welded and Rackable Ornamental Steel, Majestic, Extended Picket Style, 3-Rail style manufacturered by Ameristar Fence Products or approved equal.

B. Material:

1. Steel material for fence panels and posts shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 psi and a minimum zinc (hot-dipped galvanized) coating weight

2. Material for pickets shall be 1" square x 14 Ga. tubing. The rails shall be steel channel, 1.75" x 1.75" x .105". Picket holes in the rail shall be spaced 4.715" o.c. Fence posts and gate posts shall meet the minimum size requirements set by the manufacturer.

C. FABRICATION

1. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.

2. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail intersection by manufacturer's fusion welding process, thus completing the rigid panel assembly.

3. The manufactured panels and posts shall be subjected to an inline electrodeposition coating (E-Coat) process consisting of a multi-stage pretreatment/wash, followed by a duplex application of an epoxy primer and an acrylic topcoat. The minimum cumulative coating thickness of epoxy and acrylic shall be 2 mils. The color shall be Black. The coated panels shall meet the performance requirements of ASTM F2408.

4. The manufactured fence system shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for Industrial weight fences under ASTM F2408.

2.3 GATES

A. For Keynote 323199-B: The gate system shall conform to the Ameristar Exodus Egress Gate, Direct Bury installation method, and 1" picket with expanded metal infill, manufactured by Ameristar Perimeter Security or approved equal.

B. For Keynote 323199-C: The gate system shall conform to the Ameristar Montage II Majestic Gate.

C. MATERIAL

1. Steel material for gate framework shall be galvanized prior to forming in accordance with the requirements of ASTM A653/A653M, with minimum yield strength of 45,000 psi. The steel shall be hot-dipped galvanized to meet the requirements of ASTM A653/A653M with a minimum zinc coating weight of 0.90 oz/ft2 (276 g/m2), Coating Designation G-90.

2. Infill frame shall be 12 Ga. steel. Expanded metal mesh shall be 3/4" x #9 flattened.

3. Ornamental picket infill material shall consist of 1" square x 14 Ga. tubing for pickets. Pickets shall be spaced no greater than 5" o.c. Infill frame shall be 12 Ga. steel.

4. Gate shall be 1.75" x 14 Ga. steel reinforced structural design with 1/4" plate reinforced hinge mounting.

5. Hinges shall be stainless steel five knuckle bearing hinges with non-removable pin and stainless steel fasteners. Hinges and fasteners shall match color of gate.

D. FABRICATION

1. Gate shall be pre-drilled to accept appropriate hardware set. Infill frames shall be fabricated as a single unit. Frame shall be of welded construction inset with mesh filler, attachment to gate frame by means of security fasteners.

2. Gate jamb shall be fully welded consisting of 3" x 12 Ga. square tubing for main jamb, 1" square gate stop, and strike mounting block, with gate stop bumpers. Gate shall be pre-assemblied.

3. Gate threshold to be mounted with fasteners allowing for placement below grade or removal after installation.

4. Gate hardware to consist of exterior rated devices. Gate and hardware to be pre-assembled prior to shipping.

   a. Provide Von Duprin 99 Series Exit Device, Rockwood Pull Handle, and Norton 7500 Closer with Hold Open.

5. The manufactured galvanized gate shall be subjected to a multi-stage pretreatment/wash, followed by a dual stage coating process consisting of a cathodic electro-coat epoxy primer base coat and an electrostatic spray topcoat application, a PermaCoat powder coat system. Steel framework is subjected to a six-stage pretreatment/wash followed by an electrostatic spray application of PermaCoat Color System, a two-coat powder system. The base coat is a thermosetting epoxy powder coating. The topcoat is a "no-mar" TGIC polyester powder coat finish with a minimum thickness of 2 mils. The stratification-coated framework shall be capable of meeting the performance requirements of ASTM D3359 - Method B, ASTM B117, D714, and D1654, ASTM D2794, and ASTM D822, D2244, D523 - 60 degree Method.

2.4 ACCESSORIES

A. Caps: Cast steel galvanized; sized to post diameter, set screw retainer.

B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; steel.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Set fence posts in accordance with the manufacturer recommended spacing.

1. Posts set in concrete footers shall have a minimum depth of 36"

C. When cutting rails immediately seal the exposed surfaces by:

1. Removing metal shavings from cut area.

2. Apply zinc-rich primer to thoroughly cover cut edge and drilled hole; allow to dry.

3. Apply two coats of custom finish spray paint matching fence color.

4. Failure to seal exposed surfaces in accordance with manufacturer's instructions will negate manufacturer's warranty.

D. Space gate posts according to the manufacturers' drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected.

1. Base type and quantity of gate hinges on the application, weight, height, and number of gate cycles.

2. Identify the necessary hardware required for the application on the manufacturer's gate drawings.

3. Provide gate hardware by the manufacturer of the gate and install in compliance with manufacturer's recommendations.

E. Excavate post holes in accordance with Section 31 23 16.

3.2 TOLERANCES

A. Maximum Variation From Plumb: 1/4 inch.

B. Maximum Offset From Indicated Position: 1 inch.

C. Minimum Distance from Property Line: 6 inches.

3.3 FIELD QUALITY CONTROL

A. Layout: Verify that fence installation markings are accurate to design, paying attention to gate locations, underground utilities, and property lines.

B. Gates: Inspect for level, plumb, and alignment.

C. Workmanship: Verify neat installation free of defects.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

END OF SECTION

SECTION 32 92 00 - TURF AND GRASSES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Sodding.
   3. Erosion-control material(s).

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

C. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.

E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.4 SUBMITTALS

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

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

   1. Certification of each seed mixture for turfgrass sod, identifying source, including name and telephone number of supplier.

C. Qualification Data: For qualified landscape Installer.

D. Product Certificates: For soil amendments and fertilizers, from manufacturer.

E. Material Test Reports: For existing surface soil and imported topsoil.

F. Planting Schedule: Indicating anticipated planting dates for each type of planting.

G. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of lawns during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn establishment.
   1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
   2. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

   1. Report suitability of topsoil for lawn growth. State-recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in TPI's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

1.7 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

   1. Spring Planting: March 1 through May 15.
   2. Fall Planting: August 15 through October 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.8 MAINTENANCE SERVICE

A. Initial Lawn Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Seeded Lawns: 60 days from date of Substantial Completion.

    a. When initial maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.

2. Sodded Lawns: 60 days from date of Substantial Completion.

B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Grass Seed Mix: Blend of three varieties of Improved Tall Fescue as recommended by the Maryland Extension Service. Seed shall be Maryland Certified with seed certification tags provided to and approved by the Architect prior to installation.

2.2 TURFGRASS SOD

A. Turfgrass Sod: Certified, complying with TPI's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

1. Sun and Partial Shade: blend of three varieties of Improved Tall Fescue as recommended by the Maryland Extension Service from Maryland Certified seed.

2.3 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth.

1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

    a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.

2. Topsoil Source: Import topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.

3. Topsoil Source: Amend existing in-place surface soil to produce topsoil. Verify suitability of surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

    a. Surface soil may be supplemented with imported or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.

2.4 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural limestone containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
3. Provide lime in form of dolomitic limestone.

B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Aluminum Sulfate: Commercial grade, unadulterated.

E. Perlite: Horticultural perlite, soil amendment grade.

F. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.

G. Sand: Clean, washed, natural or manufactured, free of toxic materials.

H. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.

I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.5 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

B. Peat: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.

C. Peat: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000 percent.

D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture, free of chips, stones, sticks, soil, or toxic materials.

1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.6 PLANTING ACCESSORIES

A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.7 FERTILIZER

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.8 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Peat Mulch: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.

C. Peat Mulch: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000 percent.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 LAWN PREPARATION

A. Limit lawn subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.

a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
b. Mix lime with dry soil before mixing fertilizer.

3. Spread topsoil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

C. Unchanged Subgrades: If lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:

1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of fine texture.
    a. Apply fertilizer directly to surface soil before loosening.
3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, restore areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 5 to 8 lb/1000 sq. ft..

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with erosion-control mats where shown, installed and anchored according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Protect seeded areas from hot, dry weather or drying winds by applying mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a depth of 3/16 inch, and roll surface smooth.

3.5 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.6 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 with wood pegs spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.7 LAWN MAINTENANCE

A. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn. Provide materials and installation the same as those used in the original installation.

1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.

B. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.

2. Water lawn with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow grass to a height of 1/2 inch or less.
2. Mow grass to a height of 1/2 to 1 inch.
3. Mow grass to a height of 1 to 2 inches.
4. Mow grass to a height of 1-1/2 to 2 inches.
5. Mow grass to a height of 2 to 3 inches.

3.8 SATISFACTORY LAWNS

A. Lawn installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
2. Satisfactory Sodded Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.
3. Satisfactory Plugged Lawn: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass; and areas between plugs are free of weeds and other undesirable vegetation.
4. Satisfactory Sprigged Lawn: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants; and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.9 CLEANUP AND PROTECTION

A. Promptly remove soil and debris, created by lawn work, from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after lawn is established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION

SECTION 32 93 00 - PLANTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the following:
   1. Trees.
   2. Ground cover.
   3. Topsoil and soil amendments.
   4. Fertilizers and mulches.
   5. Stakes and guys.

B. Related
   1. Sections 311000: Site Clearing

1.3 DEFINITIONS

A. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.

B. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

C. Finish Grade: Elevation of finished surface of planting soil.

D. Planting Soil: Native or imported topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

E. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

1.4 SUBMITTALS

A. Product Data: for each type of product indicated.

B. Samples for Verification: For each of the following:
   1. 5 lb of mineral mulch for each color and texture of stone required, in labeled plastic bags.

C. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:
   1. Manufacturer's certified analysis for standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

D. Plant Photographs: Include color photographs in digital (3-by-5 inch) format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

E. Qualification Data: For landscape Installer.
   1. Installer shall have not less than 5 years documented successful experience in installation of work similar to work of the project and be a member in good standing of one of the following organizations:
      a. Landscape Contractors Association
      b. Maryland Nurseryman's Association

F. Material Test Reports: For existing surface soil and imported topsoil, if needed.

G. Planting Schedule: Indicating anticipated planting dates for exterior plants.

H. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants.
   1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when exterior planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating pH, nutrient levels (N,P,K), % organic matter, and mechanical analysis. Submit samples. Test and Reports shall be paid for by the Contractor.

   1. Acceptable soil test results:
      a. PH range: 5.5 – 7.0
      b. Organic matter: > 1.5%
      c. Magnesium: 35 pounds per acre
      d. Phosphorus: 100 pounds per acre
      e. Potassium: 85 pounds per acre
      f. Soluble salts: Not to exceed 900 ppm

D. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."
   1. Selection of exterior plants purchased under allowances will be made by Landscape Architect, who will tag plants at their place of growth before they are prepared for transplanting.

E. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches

above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

F. Observation: Landscape Architect may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
   1. Notify Landscape Architect of sources of planting materials 14 days in advance of delivery to site.
   2. Plants of the same species must be obtained from the same source.

G. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

H. Plant Substitutions: Plant substitutions will not be permitted without prior approval from the Landscape Architect.
   1. Whenever possible, the first course of action shall be to substitute with a similar cultivar of the same genus species. Caliper size of trees, height, spread, and growth characteristics of plants shall be the same as the originally specified plant.
   2. For flowering material, plant size, color, and bloom time of the proposed substitute plant shall be the same as the originally specified plant.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver exterior plants freshly dug.

B. Do not prune trees and shrubs before delivery, except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery. Handle planting stock by root ball.

C. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants trees in shade, protect from weather and mechanical damage, and keep roots moist.
   1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   2. Do not remove container-grown stock from containers before time of planting.
   3. Water root systems of exterior plants stored on-site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.7 COORDINATION

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
   1. Spring Planting: March 15 – June 15.
   2. Fall Planting: September 15 – November 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

C. Coordination with Lawns: Plant trees and shrubs after finish grades are established and

before planting lawns, unless otherwise acceptable to Landscape Architect.

1. When planting trees and shrubs after lawns, protect lawn areas and promptly repair damage caused by planting operations. Protect mulch beds from hydroseeding.

1.8 WARRANTY

A. Special Warranty: Warrant the following exterior plants, for the warranty period indicated, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by Owner, or incidents that are beyond Contractor's control.
   1. Warranty Period for all plant material: One year from date of Substantial Completion.
   2. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.
   3. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
   4. A limit of one replacement of each exterior plant will be required, except for losses or replacements due to failure to comply with requirements.

1.9 MAINTENANCE

A. Trees, Shrubs, and Perennials: Maintain for the following maintenance period by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. In the event of heavy rainfall, landscape contractor shall inspect the site for eroded mulch/plantings within five business days.
   1. Maintenance Period: 12 months from date of Substantial Completion.

PART 2 PRODUCTS

2.1 TREE AND SHRUB MATERIAL

A. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Grade: Provide trees and shrubs of sizes and grades complying with ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.

D. If formal arrangements or consecutive order of trees or shrubs is shown, select stock for uniform height and spread, and number label to assure symmetry in planting.

2.2 SHADE AND FLOWERING TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
   1. Provide balled and burlapped trees.
   2. Branching Height: One-half of tree height.

B. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
   1. Stem Form: Shrub form with a maximum of 5 canes.
   2. Provide balled and burlapped trees.

2.3 DECIDUOUS SHRUBS

A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.
   1. Provide balled and burlapped or container-grown shrubs (as per the Drawings).

2.4 CONIFEROUS EVERGREENS

A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

2.5 BROADLEAF EVERGREENS

A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.
   1. Provide balled and burlapped or container-grown shrubs (as per the Drawings).

2.6 PERENNIALS

A. Perennials: Provide healthy, field-grown plants from a commercial nursery, of species and variety shown or listed on the Drawings.

2.7 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, a minimum of 2 percent organic material content; free of stones 3/4 inch or larger in any dimension and other extraneous materials harmful to plant growth.
   1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
      a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. New topsoil shall be good friable, natural loam topsoil, containing no subsoil material, free of sticks, stones, roots, weeds, debris or other extraneous matter, and shall be obtained from an area that has never been stripped and shall have an acidity range of pH 5.0 to pH 7.0.

2.8 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
   1. Class: Class T, with a minimum 99 percent passing through No. 8 (2.36-mm) sieve and a minimum 75 percent passing through No. 60 (0.25-mm) sieve.
   2. Class: Class O, with a minimum 95 percent passing through No. 8 (2.36-mm) sieve and a minimum 55 percent passing through No. 60 sieve.
   3. Provide lime in form of dolomitic limestone.

B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through No. 6 sieve and a maximum 10 percent passing through No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Aluminum Sulfate: Commercial grade, unadulterated.

E. Perlite: Horticultural perlite, soil amendment grade.

F. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.

G. Sand: Clean, washed, natural or manufactured, free of toxic materials.

H. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.

I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.9 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50 to 60 percent of dry weight.
   2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

B. Peat: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.

C. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.10 FERTILIZER

A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.11 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Type: Shredded hardwood.

2.12 STAKES AND GUYS

A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches by length indicated, pointed at one end.

B. Guy and Tie Wire:
   1. Flat, woven polypropylene. Rounded weave and lock stitch.
   2. Made in the USA.
   3. Dimensions: ¾" (20mm) wide, varying lengths per project specifications.
   4. Color: Green.
   5. Tensile Strength: 900 lb
   6. Basis of Design: Arbor Tie (or approved equal)

C. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

2.13 PLANTING SOIL MIX

A. Planting Soil Mix: Equal quantities of existing soil (if suitable), new topsoil, and Fine Pine, or equal.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple exterior plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before planting. Make minor adjustments as required.

D. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
   1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

3.3 PLANTING BED ESTABLISHMENT

A. Loosen subgrade of planting beds to a minimum depth of 4 inches. Remove stones larger than 3/4 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply fertilizer directly to subgrade before loosening.
   2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.
      a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
      b. Mix lime with dry soil before mixing fertilizer.
   3. Spread planting soil mix to a depth of 12 inches but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
      a. Spread approximately one-half the thickness of planting soil mix over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil mix.

B. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

C. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.4 TREE AND SHRUB EXCAVATION

A. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.
   1. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
   2. If drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.

B. Subsoil removed from excavations may not be used as backfill.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
   1. Hardpan Layer: Drill 6-inch- diameter holes into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE AND SHRUB PLANTING

A. Set balled and burlapped stock plumb and in center of pit or trench with 1/8 of root ball above adjacent finish grades.
   1. Remove burlap and wire baskets from tops of root balls and partially from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   2. Place planting soil mix around root ball in 12-inch lifts, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

B. Set container-grown stock plumb and in center of pit or trench with 1/8 of root ball above adjacent finish grades.
   1. Carefully remove root ball from container without damaging root ball or plant.
   2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

C. Organic Mulching: Apply 2-inch average thickness of organic mulch placed as per the Drawings. Do not place mulch within 3 inches of tree root flare or stems.

3.6 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune

trees to retain required height and spread. Unless otherwise indicated by Landscape Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

3.7 PLANTER SOIL MIX

A. Place soil in lightly compacted layers to an elevation of 1-1/2 inches below top of planter, allowing natural settlement.
   1. Planter Soil Mix: One part topsoil, one part coarse sand, one part peat, and 3 lb of dolomitic limestone per cubic yard of mix.

3.8 PERENNIAL PLANTING

A. Set out and space plants as indicated on the Drawings or plant list.

B. Dig holes large enough to allow spreading of roots, and backfill with planting soil.

C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

E. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.9 PLANTING BED MULCHING

A. Mulch backfilled surfaces of planting beds and other areas indicated.
   1. Organic Mulch: Apply 2-inch average thickness of organic mulch, and finish level with adjacent finish grades unless otherwise specified. Do not place mulch against plant stems.

3.10 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

3.11 DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION

SECTION 33 10 00 – WATER UTILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. This Section includes water systems piping for potable water service and fire protection service outside the building.

B. Related Specifications: The following standard specifications are made a part of this specification to the extent referenced herein.

1. National Fire Protection Association "Standard for Installation of Private Fire Supply Mains and Their Appurtenances - NFPA 24."

C. Related Sections:

1. Section 312300: Excavating, Filling& Grading.

2. Refer to sections relating to fire protections systems and water distribution systems in Division 22.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Pressure Rating: Except where otherwise indicated, the following are minimum pressure requirements for water system piping.

1. Underground Piping: 280 psig with an actual operating pressure of 125 psig.

2. All materials shall be in accordance with the requirements of the Baltimore City Plumbing Code and the Baltimore City Department of Public Works.

1.4 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division I Specification Sections.

B. Product data for the following:

1. Identification materials and devices.

C. Coordination drawings showing pipe sizes and elevations. Include details for connections, anchors, and reaction backing. Show other piping in same trench and clearances from water system piping. Indicate interface and spatial relationship between piping and proximate structures.

D. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Project Closeout."

E. Test reports specified in "Field Quality Control" Article in Part 3.

1.5 QUALITY ASSURANCE

A. Comply with standards of authorities having jurisdiction for fire protection systems. Include materials, hose threads, installation, and testing.

B. Comply with standards of authorities having jurisdiction for potable water piping and plumbing systems. Include materials, installation, testing, and disinfection.

C. Comply with NFPA 24 "Standards for the Installation of Private Fire Service Mains and Their Appurtenances" for materials, installations, tests and flushing.

D. Listing and Labeling: Provide equipment and accessories that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in "National Electrical Code," Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

E. Product Options: Water systems specialties and accessories are based on specific types, manufacturers, and model indicated. Components by other manufacturers but having equal performance characteristics may be considered, provided deviations in dimensions, operation, and other characteristics do not change design concept or intended performance as judged by Engineer. The burden of proof of equality of products is on Contractor. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

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

1.7 PROJECT CONDITIONS

A. Site Information: Data in subsurface investigation repots was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil bores. The Engineer, will not be responsible for interpretations or conclusions drawn from this data by the Contractor.

1. Additional test bores and other exploratory operations may be performed by the Contractor, at the Contractor's option; at no additional cost to the Engineer.

B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Engineer or others except when permitted in writing by the Engineer and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Engineer.

1. Provide a minimum 48-hours' notice to the Engineer and receive written notice to proceed before interrupting any utility.

C. Should uncharted or incorrectly charted, piping, or other utilities be encountered during excavation, consult utility Engineer immediately for directions. Cooperate with Engineer and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of Engineer.

D. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Open trench excavations within the limits of the State right-of-way shall be protected in accordance with the requirements of applicable permits. Open excavation within other roadways shall be plated and shall be posted with warning devices in accordance with the Manual on Uniform Traffic Control Devices.

1. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dry out to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

2. Work which affects the public right-of-way shall be in accordance with the Baltimore City Department of Public Works requirements and regulations.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with pipe materials, sizes, entry locations, and pressure requirements of building fire protection systems piping.

B. Coordinate with pipe materials, sizes, and entry locations, and pressure requirements of building water distribution systems piping.

C. Coordinate with other utility work.

D. Coordinate electrical requirements of actual equipment furnished with requirements specified in Division 26.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with the requirements of the Engineer, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

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

1. Drilling Machine Corporation Stops:
   a. Ford Meter Box Co., Inc.
   b. Hays Div., Romac Industries
   c. Mueller Co., Grinnell Corp.

2. Bronze Corporation Stops and Valves:
   a. Ford Meter Box Co., Inc.
   b. Hays Div., Romac Industries
   c. A.Y. McDonald Mfg. Co.
   d. Mueller Co., Grinnell Corp.

3. Tapping Valves:
   a. A.P. Smith Manufacturing Company
   b. M & H Valve & Fittings Company

4. Gate Valves:
   a. A.P. Smith Manufacturing Company
   b. M & H Valve & Fittings Company

5. Dry-Barrel Fire Hydrants:
   a. American Darling Valve Company Model B-62-B
   b. Dresser Manufacturing Company Reliant Style 929
   c. Kennedy Valve Company Guardian Model K-81
   d. Mueller Co. A-463 Centurian
   e. U.S. Pipe & Foundry Co. Smith Model H 205

6. Drains:
   a. Ancon, Inc.
   b. Jones Manufacturing Co., Inc.
   c. Josam Co.
   d. Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
   e. Wade Div., Tyler Pipe Subsid., Tyler Corp.
   f. Zurn Hydromechanics Div., Zurn Industries, Inc.

7. Detector Check Valves:
   a. Ames Co., Inc.
   b. Hersey Products, Inc., Grinnell Corp.
   c. Kennedy Valve Div., McWane, Inc.
   d. Viking Corp.
   e. Watts Regulator Co.

8. Backflow Preventers:
   a. Ames Co., Inc.

b. Cla-Val Co. Div., Griswold Industries
c. Conbraco Industries, Inc.
d. Febco.
e. Hersey Products, Inc., Grinnell Corp.
f. Watts Regulator Co.
g. Wilkins Regulator Div., Zurn Industries, Inc.

2.2 PIPES AND TUBES

A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube materials specified below are used.

B. Ductile-Iron Pipe: AWWA C151, Class 54.

1. Lining: AWWA C104, cement mortar, seal coated.

2. Gaskets, Glands, and Bolts and Nuts: AWWA C111.

3. Mechanical-Joint-Type Pipe: AWWA C111, rubber gaskets, ductile retain- or glands, and steel bolts and nuts.

4. Encasement: AWWA C105, polyethylene film tube.

C. Copper Tube: ASTM B 88, Types K (ASTM B 88M, Types A and B), seamless water tube, annealed temper.

2.3 PIPE AND TUBE FITTINGS

A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube fitting materials specified below are used.

B. Ductile-Iron Pipe Fittings Class D or Class 250: AWWA C110, ductile-iron, 250-psig (1725-kPa) minimum pressure rating; or AWWA C153, ductile-iron compact fittings, 350-psig (2400-kPa) pressure rating.

1. Lining: AWWA C104, cement mortar.

2. Gaskets: AWWA C111, rubber.

C. Polyethylene Encasement: AWWA C105, 8-mils. (2 mm) minimum thickness, tube or sheet.

2.4 JOINING MATERIALS

A. Refer to Part 3 Article "Piping Applications" for identification of systems where joining materials specified below are used.

B. Ductile-Iron Pipe and Ductile-Iron Fittings: The following materials apply:

1. Mechanical Joints: AWWA C111 ductile-iron retainer glands, high-strength steel bolts and nuts, and rubber gaskets.

2.5 PIPING SPECIALTIES

A. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150-psig (1035-kPa) or 300-psig (2070-kPa) minimum pressure to suit system pressures.

B. Dielectric-Flange Insulation Kits: Field-assembled companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Provide separate companion flanges and steel bolts and nuts for 150-psig (1035-kPa) or 300-psig (2070-kPa) minimum working pressure to suit system pressures.

2.6 VALVES

A. Valves shall be in accordance with the latest requirements of the Engineer.

B. Valve Boxes: Concrete Sectional Vaults having frame and cover with lettering "Water Valve," in accordance with the Engineers' standards.

C. Tapping Sleeve and Tapping Valve: Shall be in accordance with the latest requirements of the Engineer.

D. Service Clamps and Corporation Stops: Complete assembly, including service clamp, corporation stop, and bolts and nuts. Use service clamp and stop compatible with drilling machine.

1. Service Clamp: Cast iron or ductile iron with gasket and AWWA C800 threaded outlet for corporation stop, and threaded end straps.

2. Corporation Stops: Bronze body and ground key plug, with AWWA C800 threaded inlet and outlet matching service piping material.

3. Manifold: Copper with 2 to 4 inlets as required, with ends matching corporation stops and outlet matching service piping.

2.7 WATER METERS

A. General: Provide water meter with registration in gallons.

B. Domestic Water Meter: As approved by Engineer.

C. Fire Service Water Meter: As approved by Engineer.

2.8 PITS

A. Concrete: Portland cement mix, 3000 psi (20.7 MPa).

1. Cement: ASTM C 150, Type I.

2. Fine Aggregate: ASTM C 33, sand.

3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable.

B. Reinforcement: Steel conforming to the following:

1. Fabric: ASTM A 185, welded wire fabric, plain.

2. Reinforcement Bars: ASTM A 615, Grade 60 (ASTM A 615, Grade 400), deformed.

3. Ladder: ASTM A 36 (ASTM A 36M), steel or polyethylene-encased steel steps.

4. Manhole: ASTM A 48, Class 35, gray-iron, 24-inch (610-mm) minimum diameter traffic frame and cover, of size and weight indicated.

5. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron, 24-inch (610-mm) minimum diameter traffic frame and cover, of size and weight indicated.

6. Drain: ASME A112.21.1M, cast-iron area drain, of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.9 FIRE HYDRANTS

A. General: "Traffic Model", cast-iron body, compression-type valve, opening against pressure and closing with pressure, 6-inch (DN 150) mechanical joint inlet, 150-psig (1035-kPa) working pressure.

B. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.

C. Operating and Cap Nuts: Pentagon 1-3/8 inch (3.5 cm) point to flat.

D. Direction of Opening: Open hydrant valve by turning operating nut to the left, or counterclockwise. Show direction of the opening on the bonnet with a raised arrow.

E. Finish: Sherwin Williams, Kem L-F65, E-36, Safety Orange Lead Free Industrial Enamel or approved equal.

F. Dry-Barrel Fire Hydrants: UL 246, FM-approved, two 2-1/2 inch (6.35 cm) and one 4-1/2 inch (11.4 cm) outlets, 5-inch (12.7 cm) min. main valve, drain valve, and 6-inch mechanical joint inlet and a flanged connection on the stand pipe end.

2.10 ANCHORAGES AND BUTTRESSES

A. General: All anchorages and buttresses shall be in conformance with the Baltimore City Specifications and Standard Details.

B. Concrete Reaction Backing: Portland cement mix, 3000 psi.

1. Cement: ASTM C 150, Type I.

2. Fine Aggregate: ASTM C 33, sand.

3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable

2.11 IDENTIFICATION

A. Metallic-Lined Plastic Underground Warning Tapes: polyethylene plastic tape with metallic core, 6 inches wide, by 4 mils thick, solid blue in color with continuously printed caption in black letters "CAUTION - WATER LINE BURIED BELOW".

PART 3 EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section 312300.

3.2 SERVICE ENTRANCE PIPING

A. Extend water system piping from the existing public main to a point within 5' of the proposed building.

1. Terminate water system piping from the proposed public main to a point within 5' of the proposed buildings for fire protection.

B. Water distribution systems and fire protection systems are specified in Division 15 Sections. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods."

3.3 PIPING APPLICATIONS

A. Refer to Part 2 of this Section for detailed specifications for pipe and fittings products listed below. Use pipe, tube, fittings, and joining methods according to the following applications. Piping in pits and inside building may be joined with flanges or couplings, instead of joints indicated, for grooved-end AWWA-size piping.

B. Use pipe, tube, fittings, and joining methods according to following applications:

1. 4 inches (DN 100) to 8 inches (DN 200): Class D or Class 250, ductile-iron pipe, ductile-iron compact fittings, and mechanical joints with retainer glands.

3.4 JOINT CONSTRUCTION

A. Ductile-Iron Piping Gasketed Joints: Construct joints according to AWWA C600.

B. Flanged Joints: Align flanges and install gaskets. Assemble joints by sequencing bolt tightening. Use lubricant on bolt threads.

C. Threaded Joints: Thread pipes with tapered pipe threads according to ASME B1.20.1, apply tape or joint compound, and apply wrench to valve ends into which pipes are being threaded.

D. Dissimilar Materials Piping Joints: Construct joints using adapters that are compatible with both piping materials, outside diameters, and system working pressure. Refer to "Piping Systems - Common Requirements" Article for joining piping of dissimilar metals.

3.5 PIPING SYSTEMS - COMMON REQUIREMENTS:

A. Installation: Installation shall be in accordance with the Baltimore City Specifications; NFPA 24; the Baltimore City Plumbing Code; and the written recommendations of the pipe manufacturer, except that in the case where there are conflicts among the provision of the various installation requirements, the more stringent or restrictive requirements shall govern.

B. General Locations and Arrangements: Drawings indicate general locations and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated except where deviations to layout are approved on coordination drawings.

C. Install components having pressure rating equal to or greater than system rated pressure (200 psig).

D. Install piping free of sags and bends.

E. Install fittings for changes in direction.

F. Piping Connections: Except as otherwise indicated, making piping connections as specified below.

1. Install flanges, in piping 2-1/2 inches and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

2. Install dielectric fittings to connect piping of dissimilar metals.

3.6 PIPING INSTALLATION

A. Comply with requirements of NFPA 24 for materials and installation.

1. Bury piping at minimum depth of 48 inches below finished grade, and not less than 18 inches below average local frost depth.

3.7 ANCHORAGE INSTALLATION

A. Anchorages: Install anchorages for tees, plugs/caps, and bends. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron Piping: According to AWWA C600.

B. Apply full coat of asphalt or other acceptable corrosion retarding to surfaces of installed ferrous anchorage devices.

C. Anchorage blocks shall be constructed of a poured reinforced concrete pad, which partially encapsulates the fitting and prevents any relative movement between the straight section of the fitting and the branch section.

3.8 IDENTIFICATION INSTALLATION

A. Install continuous plastic underground warning tape during back filling of trench for underground water service piping. Locate 6 inches to 8 inches below finished grade, directly over piping.

3.9 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after thrust blocks have hardened sufficiently. Fill pipeline 24 hours prior to testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than 2 times operating pressure for 2 hours.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 1000 joints. Remake leaking joints with new materials and repeat test until leakage is within above limits.

C. Tests and reports are engaged and paid for by the contractor at no additional cost to the Engineer.

3.10 CLEANING

A. Clean and disinfect water distribution piping as follows:

1. Purge new water distribution piping systems and parts of existing systems that have been altered, extended, or repaired prior to use.

2. Use purging and disinfecting procedures prescribed by Baltimore City Specifications and NFPA.

B. Prepare reports for purging and disinfecting activities.

END OF SECTION

SECTION 33 40 00 – STORM DRAINAGE UTILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Requirements of the Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to all work under this section.

B. All materials and construction methods shall be in accordance with the City of Baltimore "Standard Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures," 2006 edition, hereinafter referred to as the "Standard Specifications," City of Baltimore Standard Details March 2008 and as amended on the drawings.

C. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Engineer for consideration. Those judged to be equal to that specified will receive written approval.

1.2 SUMMARY

A. This Section includes drainage systems five feet (5') outside the building. Systems include the following:

1. Storm drainage

2. Stormwater Management Facility

B. Related Sections:

1. Section 312300; Excavating, Filling & Grading.

2. Refer to sections relating to plumbing piping, drainage and vent systems and laboratory systems in Division 22.

1.3 DEFINITIONS

A. Drainage Piping: System of sewer pipe, fittings, and appurtenances for gravity flow of storm drainage.

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Non-pressure-Piping Pressure Ratings: At least equal to system test pressure.

B. Stormwater Management Permit: Stormwater management facilities shall be constructed in accordance with the approved drawings and the provisions of the Stormwater Management Permit. The Engineer will obtain the Stormwater Management Permit prior to construction of the facility.

C. Certification of Completed Facilities: As-Built Plans and Certifications are required for the stormwater management facilities. In order to properly prepare these documents, this stormwater management facility must be inspected by a Registered Professional Engineer at specific stages of the construction. The Contractor shall notify the Engineer's Testing and Inspection Engineer at least five (5) working days prior to starting work on this stormwater management facility. The Contractor shall provide an As-Built survey of all of the stormwater management facilities, signed and sealed by a Maryland Registered Surveyor. Preparation and processing of the As-Built Plans and Certification will be the responsibility of the Engineer.

1.5 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of product indicated.

C. Product Certificates: For each type of pipe and fitting, from the manufacturer.

D. Shop drawings for precast concrete manholes and other structures. Include frames, covers and grates.

E. Shop drawings for the various types of piping.

F. Shop drawings for cast-in-place concrete or field-erected masonry manholes and other structures. Include frames, covers and grates.

G. Reports and calculations for design mixes for each class of cast-in-place concrete.

H. Inspection and test reports specified in the, "Field Quality Control," Article.

1.6 QUALITY ASSURANCE

A. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems.

B. Utility Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems. Include standards of water and other utilities where appropriate.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic structures in direct sunlight.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, pipefittings, and seals from dirt and damage.

D. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.

E. Stone to be delivered and placed immediately in the water quality facility and protected from soil contamination.

1.8 PROJECT CONDITIONS

A. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as presentations or warranties of accuracy or continuity between soil borings. The Engineer will not be responsible for interpretations or conclusions drawn from this data by the Contractor.

1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.

B. Locate existing structures and piping to be closed and abandoned.

C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Engineer or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.

1. Notify Engineer not less than 48 hours in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without receiving Engineer's written permission.

D. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility Engineer immediately for directions. Cooperate with Engineer and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility Engineer.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate with interior building drainage systems.

B. Coordinate with other utility work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

1. Cleanouts
   a. Ancon, Inc.
   b. Jones Manufacturing Co., Inc.
   c. Josam Co.
   d. Rockford Sanitary Systems, Inc.
   e. Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
   f. Wade Div., Tyler Corp.
   g. Zurn Industries, Inc., Hydromechanics Div.

2.2 PIPES AND FITTINGS

A. High Density Polyethylene (HDPE) Pipe and Fittings Hancor Blue Seal Water Tight: As manufactured by Advanced Drainage Systems, Inc. or approved equal.

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, Class IV, Wall B, for gasketed joints.

1. Gaskets: ASTM C 443, rubber.

C. Polyvinylchloride (PVC): Schedule 40, watertight.

2.3 SPECIAL PIPE COUPLINGS AND FITTINGS

A. Sleeve-Type Pipe Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined, for Non-pressure joints.

1. Sleeves for Concrete Pipe: ASTM C 443 (ASTM C 443M), rubber.

2. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.

3. Sleeves for Dissimilar Pipes: Compatible with pipe materials being joined.

4. Bands: Stainless steel, at least one at each pipe insert.

2.4 MANHOLES

A. Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints, and frame and cover, all in accordance with Baltimore City Standard Details. Cast iron frame and cover shall be minimum H20 loading. Include indented top design with lettering, equivalent to the following, cast into cover:

1. Storm Drainage Piping Systems: "STORM DRAIN."

2.5 STORM DRAIN INLETS

A. General: Pre-cast reinforced concrete, or cast-in-place concrete complete with frames and grates, all in accordance with Baltimore City Standard Details unless otherwise noted on the contract drawings. Cast iron frame and grate shall be minimum H20 loading.

2.6 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.

2. Fine Aggregate: ASTM C 33, sand.

3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable.

B. Structures: Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.

2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

C. Structure Channels and Benches: Factory or held formed from concrete. Portland-cement design mix, 4000-psi minimum, with 0.45 maximum water-cement ratio.

1. Include channels and benches in manholes.
   a. Manholes Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, uniform radius and slope.
      1) Invert Slope: 2.5 percent (1:40) through manhole.
      2) Manhole Benches: Concrete, sloped to drain into channel.
         a) Slope: 1 inch per foot (1:12).
   b. Include channels and benches in storm drain inlets.
      1) Storm Drain Inlet Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, uniform radius and slope.
         a) Invert Slope: 2.5 percent (1:40) through inlet.
      2) Storm Drain Inlet Benches: Concrete, sloped to drain into channel.
         a) Slope: 1 inch per foot (1:12).

2. Ballast and Pipe Supports: Portland-cement design mix, 3000-psi minimum, with 0.58 maximum water-cement ratio.
   a. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
   b. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

2.7 PROTECTIVE COATINGS

A. General: Include factory - or field-applied protective coatings to structures and appurtenances according to the following:

B. Coating: Apply 2-coats, coal-tar epoxy, 15-mil minimum thickness, except where otherwise indicated.

1. Manholes: On exterior surfaces.

2. Storm Drain Inlets: On exterior surfaces.

2.8 CLEANOUTS

A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and found, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug. Use units with top-loading classifications according to the following applications:

1. Light Duty: In earth or grass, foot-traffic areas.

2. Medium Duty: In paved, foot-traffic areas.

3. Heavy Duty: In vehicle-traffic service areas.

B. Pipe Fitting and Riser to Cleanout: ASTM A 74, service class, cast-iron soil pipe and fittings.

C. Cleanouts located in paved areas shall have countersunk lids.

2.9 RIPRAP

A. Stone for riprap shall be uniformly graded from the smallest to the largest pieces as specified in the Contract Documents. The stone will be accepted upon visual inspection at the point of usage, and shall conform to the following:

Table 334000-1

Class of Riprap	Weight Ranges lb (kg)	Approx. Size in. (mm)
0	1-33 (0.5 - 15)	2-7 (50 - 175)
I	2-150 (1 - 70)	3-12 (75 - 300)
II	20-700 (10 - 320)	6-20 (150 - 500)
III	40-2000 (20 - 910)	8-28 (200 - 700)

2.10 GEOTEXTILES

A. Geotextiles shall conform to the class specified in the Contract Documents. The geotextile shall be manufactured from fibers consisting of long chain synthetic polymers, composed of a minimum 85 percent by weight of polyolephins, polyesters or polyamides. The geotextile shall resist deterioration from ultraviolet exposure. Geotextiles used in the construction of silt fence shall contain sufficient amounts of ultraviolet ray inhibitors and stabilizers to provide a minimum of 12 months of expected usable construction life at a temperature range of 0 to 120F (-18 to 49 C).

B. All values specified are minimum or maximum roll values.

C. Classes A through E Geotextiles shall have a 0.010 cm/sec minimum permeability when tested in conformance with D4491, and an apparent minimum elongation of 20 percent when tested for conformance with the grab tensile strength requirements specified below. Classes A through E Geotextiles shall also conform to the following additional requirements:

Table 334000-2

Geotextile Class	Maximum Apparent Opening Size (mm)	Grab Tensile Strength lb (N) min	Minimum Burst Strength psi (MPa)
A	0.30	250 (110)	500 (3.4)

Table 334000-2			
Geotextile Class	**Maximum Apparent Opening Size (mm)**	**Grab Tensile Strength lb (N) min**	**Minimum Burst Strength psi (MPa)**
B	0.60	200 (890)	320 (3.2)
C	0.30	200 (890)	320 (2.2
D	0.60	90 (400)	145 (1.0)
E	0.30	90 (400)	145 (1.0)

D. Class F Geotextiles (Silt Fence) shall have a 50 lb./in. (8.8kN/m) minimum tensile strength and a 20 lb/in. (3.5kN/m) minimum tensile modulus when tested in conformance with D4595. The material shall also have a 0.3 gal/ft□(12.21/m□) per minute minimum flow rate and a 75 percent minimum filtering efficiency when tested in conformance with D 5141.

E. The properties shall be determined as follows:

Table 334000-3	
Test	**Method**
Apparent Opening Size	D 4751
Grab Tensile Strength	D 4632, Grab Test – 4 x 8 in. (100 x 200 mm) specimen, 1 x 2 in. (25 x 50 mm) clamps; 12 in. (300 mm)/minute strain rate both principal directions of geotextile.
Burst Strength	D 3786

1. Sewing of the geotextile will be allowed provided it conforms to the following:
   a. Seams shall be either "J" or "butterfly" type and shall utilize a lock stitch.
   b. Seams shall conform to the tensile strength requirements for the geotextile when tested across the seam.
   c. The thread for seaming shall be of equal or greater durability than the geotextile itself.

PART 3 EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section 312300- "Excavating and Filling."

3.2 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section 312300. Arrange for installation of green detectable warning tapes directly over piping and at outside edges of underground structures.

3.3 PIPING APPLICATIONS

A. General: Include watertight, silt-tight, or soil-tight joints, except where watertight or silt-tight joints are indicated.

B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to the following applications.

C. Corrugated Polyethylene (HDPE), Hancor Blue Seal corrugated polyethylene pipe installed per manufacturers' specifications.

D. Reinforced-concrete sewer pipe and fittings; rubber gaskets; and gasketed joints.

3.4 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

A. Special Pipe Couplings: Use where indicated and where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

1. Use the following pipe couplings for non-pressure applications:
   a. Strait-pattern, sleeve type to join piping, of same size, with small difference in outside diameters.
   b. Increaser/reducer-pattern, sleeve type to join piping of different sizes.
   c. Gasket type to join piping of different sizes where annular space between smaller piping's outside diameter and larger piping's inside diameter permits installation.
   d. Internal-expansion type to join piping with same inside diameter.

B. Special Pipe Fittings: Use where indicated.

3.5 INSTALLATION, GENERAL

A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical and in accordance with the requirements of the Baltimore City Specifications and in accordance with the pipe manufacturer's written instructions. Where installation details are not shown on the Drawings, installation shall be in accordance with the Baltimore City Standard Details.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. Use manholes for changes in direction.

D. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited, except as indicated on the plans.

E. Install piping at constant slope between points and elevations indicated. Install straight piping runs at constant slope, not less than that specified, where slope is not indicated.

F. Extend piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.

G. Install piping pitched down in direction of flow, at minimum slope of 1 percent (1:100) and 36-inch minimum cover, except where otherwise indicated.

3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION

A. General: Join and install pipe and fittings according to the following.

B. Corrugated Polyethylene (HDPE) Plastic Pipe and Fittings: Join and install in accordance with manufacturer's instructions.

C. Concrete Pipe and Fittings: Install according to ACPA "Concrete Pipe Handbook". Use the following seals:

1. Round Pipe and Fittings: ASTM C 443 (ASTM C 443M), rubber gaskets.

D. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and fit both systems materials and dimensions.

3.7 MANHOLE INSTALLATION

A. General: Install manholes, complete with accessories, as indicated.

B. Form continuous concrete channels and benches between inlets and outlet, where indicated.

C. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches above finished surface elsewhere, except where otherwise indicated.

D. Place precast concrete manhole sections as indicated, and install according to ASTM C 891.

1. Provide rubber joint gasket complying with ASTM C 443, at joints of sections.

2. Apply bituminous mastic coating at joints of sections.

E. Construct cast-in-place manholes as indicated.

3.8 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318, ACI 350R, and as indicated.

3.9 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

B. Set cleanout frames and covers in concrete paving with tops flush with Surface of paving.

C. Cleanouts located in paving shall have countersunk lids.

3.10 CLOSING ABANDONED DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping that is indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either of the following procedures:

1. Close open ends of piping with at least 8-inch-thick brick masonry bulkheads.

2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Structures: Excavate around structure as required and use either of the following procedures:

1. Remove structure and close open ends of remaining piping.

2. Remove top of structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

3. Backfill to grade according to Division 2 Section 312300 - "Excavation, Filling & Grading."

3.11 FIELD QUALITY CONTROL

A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.

2. Place plug in end of incomplete piping at end of day and whenever work stops.

3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of the Project at no additional cost to the Engineer.

1. Submit separate reports for each system inspection.

2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visual between structures.
b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.

4. Re-inspect and repeat procedures until results are satisfactory.

C. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects at no additional cost to the Engineer.

1. Do not enclose, cover, or put into service before inspection and approval.

2. Test completed piping systems according to authorities having jurisdiction.

3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours advance notice.

4. Submit separate reports for each test.

5. High density polyethylene "HDPE" pipe: Perform testing in accordance with manufacturer's recommendations.

6. Where authorities having jurisdiction do not have published procedures, perform tests as follows:
   a. Storm Drainage: Perform hydrostatic test.
      1) Allowable leakage is a maximum of 200 gallons per inch nominal pipe size, for every mile of pipe, during a 24-hour period.
      2) Close openings in system and fill with water.
      3) Purge air and refill with water.
      4) Disconnect water supply.
      5) Test and inspect joints for leaks.
      6) Option: Test ductile-iron piping according to AWWA C600, Section 4 "Hydrostatic Testing." Use test pressure of at least 5 psig.
      7) Option: Test concrete piping according to ASTM C 969.
      8) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
   b. Storm Drainage: Perform hydrostatic test. Close openings in system and fill with water to not less than 10-foot head of water. Disconnect water supply. Water level must not drop for 15 minutes. Inspect joints for leaks.
      1) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
   c. Storm Drainage: Perform air test according to UNI-B-6.
      1) Option: Test round concrete piping, 24 inches and smaller, according to ASTM C 924.
      2) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.

7. Manholes: Perform hydraulic test according to ASTM C 969.

8. Leaks and loss in test pressure constitute defects that must be repaired.

9. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

END OF SECTION