PROJECT MANUAL

Curry County Livestock Pavilion
Curry County | Clovis, New Mexico

Project No: 23-0003
Owner's Project No: 2022/23-11

Project Manual

Volume 3 of 3

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SECTION 22 0504 - PIPE AND PIPE FITTINGS FOR PLUMBING

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

1.03 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 PRODUCTS

See Division 23, Section 23 0504 – Pipe and Pipe Fittings, for applicable requirements.

PART 3 EXECUTION

See Division 23, Section 23 0504 – Pipe and Pipe Fittings, for applicable requirements.

END OF SECTION

SECTION 22 0505 - PIPING SPECIALTIES FOR PLUMBING

PART 1 GENERAL

1.01 REQUIREMENTS

A. Contractor shall furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0523, Valves for Plumbing.

D. Section 22 0700, Plumbing Insulation.

1.03 SUBMITTAL DATA

A. The Contractor shall furnish complete submittal data for all piping specialties including manufacturer's specifications, performance characteristics, ratings, installation instructions, certifications and approvals of listing agencies, wiring diagrams, and selection analysis.

PART 2 PRODUCTS

See Division 23, Section 23 0505, Piping Specialties.

PART 3 EXECUTION

See Division 23, Section 23 0505, Piping Specialties.

END OF SECTION

SECTION 22 0523 - VALVES FOR PLUMBING

PART 1 GENERAL

1.01 REQUIREMENTS

A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.

C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Division 21 for Fire Suppression System.

D. Division 22 for Plumbing.

1.03 SCOPE

A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.04 VALVE REQUIREMENTS

A. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Grinnell, or equivalent.

B. All lubricated plug valves shall be as manufactured by Rockwell, Walworth, Homestead, or equivalent.

C. Ball valves shall be utilized in lieu of gate valves and globe valves for all plumbing systems for sizes 2" and smaller.

D. All valves Furnish under Division 22 and 23 of the same type shall be products of a single manufacturer unless otherwise approved by Owner's Representative.

E. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

PART 2 PRODUCTS

See Division 23, Section 23 0523 - Valves, for applicable requirements.

PART 3 EXECUTION

See Division 23, Section 23 0523 - Valves, for applicable requirements.

END OF SECTION

SECTION 22 0700 - PLUMBING INSULATION

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.
B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.
C. Section 23 0700, Mechanical Systems Insulation

1.03 SCOPE

All condensate pipe and fittings domestic hot water pipe and circulating hot water, domestic cold water, and water piping located outdoors exposed to ambient freezing conditions or in the pavilion space.

1.04 SUBMITTALS

A. See Division 23, Section 23 0700 – Mechanical Systems Insulation, for applicable requirements.

1.05 TESTING

A. All piping shall be tested in accordance with the applicable Specification Sections, before any insulation is applied.

PART 2 PRODUCTS

See Division 23, Section 23 0700 – Mechanical Systems Insulation, for applicable requirements.

PART 3 EXECUTION

See Division 23, Section 23 0700 – Mechanical Systems Insulation, for applicable requirements.

END OF SECTION

SECTION 22 1100 - DOMESTIC WATER PIPING

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with the applicable provisions of the General Conditions, Supplemental General Conditions, and the General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead. Solder shall be 95/5 tin antimony, alloy Sb5, conforming to FS QQ-S-571 and NSF 61.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0505, Piping Specialties for Plumbing.

D. Section 22 0523, Valves for Plumbing.

E. Section 22 0700, Plumbing Insulation.

F. Section 22 6801, Onsite Utilities, Plumbing.

G. Section 23 0900, Facility Management System.

H. Division 33 for Outside Utilities.

1.03 SCOPE

A. A complete domestic cold water, hot water, recirculating hot water, and make-up water system including water heaters, pumps, thermal expansion tanks, meters, backflow protection, pressure reducing valves, shock absorbers, and associated miscellaneous accessories. This section shall include all work within the building to a point approximately 5'-0" outside the building, or as otherwise indicated.

B. Coordinate with Division 33 for site utility drawings and specifications.

PART 2 PRODUCTS

2.01 PIPING

A. Domestic water piping including below grade or slab-on-grade shall be Type L soft copper, ASTM B88. Copper piping 2" and smaller shall be soft tubing and 2-1/2" thru 4" shall be either soft tubing or hard pipe. Domestic water piping 6" and larger below grade within the building and to a point approximately 5'-0" from the building shall be ductile iron pressure pipe, minimum 150 PSIG working pressure with mechanical joints.

B. Domestic water piping above grade within the building 4" and smaller shall be Type L hard drawn copper, ASTM B88. Domestic water piping larger than 4" shall be copper as specified herein.

C. Proper insulating fittings, as specified in Section 22 0504, shall be installed to prevent electrolytic action between steel and copper piping connections.

2.02 FITTINGS

A. Fittings for copper piping shall be wrought copper or cast brass conforming to ANSI B16.22 and B16.23, with 95-5 solder joints, as specified in Section 22 0504.

B. Mechanically formed tee connections and couplings for copper piping system as specified in Section 22 0504, may be utilized where approved.

C. Fittings for ductile iron pipe shall be flanged or mechanical joint conforming to ANSI/AWWA C110 and C111, Class 250 minimum, cement lined, with bituminous coating.

2.03 FLANGES

A. Flanges for copper piping systems shall be Class 150 wrought copper or cast brass conforming to ANSI B16.24.

B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.

C. Flanges for galvanized steel piping system shall be galvanized cast or malleable iron Class 125, standard threaded plain face companion flanges for flanged connections in threaded piping systems.

D. Gaskets shall be 1/16" thick ring type or full face non-asbestos material suitable for the temperatures and pressure application.

E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.04 JOINTS

A. Joints in copper piping system shall be made using approved "lead-free" solder and flux as described herein and approved by all applicable codes and regulations. Surfaces to be soldered shall be cleaned bright by manual or mechanical means.

B. All joints shall be properly fluxed with a non-corrosive "lead-free" type flux manufactured to approved standards, Federal Specification QQ-S-517. Joints for copper piping systems for cold water 3" and smaller and hot water 2" and smaller shall be made using composition 95-5 tin-antimony solder. Composition 15% silver solder shall be used for all other piping sizes and for all underground joints.

2.05 SHOCK ABSORBERS

A. Furnish and install factory sealed shock absorbers conforming to Federal Specification WW-P-541 at locations shown on the drawings and/or as outlined by Plumbing Drainage Institute Standard WH-201. Josam, Precision, Jay R. Smith, Wade, Watts, Zurn or equivalent.

2.06 DOMESTIC HOT WATER GENERATING EQUIPMENT

A. Water heaters and associated auxiliary equipment shall be as specified on the equipment schedule on the drawings. Natural gas fired or electric domestic water heaters shall be as manufactured by Bock, Bradford-White, Lochinvar, P.V.I., Ruud, Rheem, A.O. Smith, State, or equivalent.

B. Electric instantaneous water heaters shall be by Chronomite, Eemax, Hubbell, Keltech, Rheem, Stiebel Eltron, State, or equivalent.

C. Furnish and install approved expansion tank on cold water make-up supply to hot water generating equipment as recommended by manufacturer or as shown on the drawings and specified in the plumbing equipment and fixture schedule on the drawings, Amtrol, Wilkins, or approved equal.

D. The Contractor shall provide the services of a qualified factory-trained representative to supervise hot water generation system start-up and instruct the Owner’s operating personnel for a minimum of eight (8) hours. A full one (1) year service warranty, including all parts and labor, shall be provided by the Contractor.

E. Natural gas fired domestic hot water boilers and water heater combustion flues, stack, breeching, and combustion air louvers, ducts, etc., shall be provided under Division 23.

2.07 VALVES

A. Valves other than automatic control valves are specified in Section 22 0523, Valves.

B. Automatic control valves shall be as specified in Section 23 0900, Facility Management System, except for automatic control valves furnished as a part of equipment packages, including hot water generating equipment, as specified on the equipment schedule.

2.08 PUMPS

A. Pumps shall be of the type and capacity listed in the equipment schedule. Pumps shall be selected so that the motors will not overload under any operating condition. Furnish one spare mechanical seal of each size required in conjunction with the pumps furnished under this Contract. All base mounted pumps shall have drain pans with tapped pipe connections and 3/4" drain line extended to floor drain. Pumps shall be installed so that they may be removed without the removal of the associated piping. All pumps for potable water applications shall have bronze or stainless steel body and trim.

B. Domestic water inline re-circulating pumps shall be as specified on the drawings and as manufactured by Armstrong, Bell & Gossett, Taco, Thrush, or equivalent.

C. Manufacturer shall furnish a full one (1) year warranty, including all parts and labor for the water pressure booster pumping system.

2.09 WATER METER

A. See Division 33 for water meters.

2.10 BACKFLOW PROTECTION

A. All cross-contamination control shall be provided to ensure that no installation of the potable water supply piping system shall be made in a manner that will allow used, unclean, polluted, or contaminated water or substances to enter the domestic potable water system.

B. All backflow devices and assemblies shall be approved by the applicable Administration Authorities and shall be installed according to all applicable codes, regulations, and manufacturer's instructions. Installation shall allow for required access and clearance for required testing, maintenance, and repair.

C. Reduced pressure backflow preventer assembly shall be furnished and installed by the Contractor. Backflow preventer size and arrangement shall be as indicated on the drawings, and shall be as manufactured by Zurn, Febco, Hersey, Beeco, Watts, Wilkins, or equivalent. All

costs, fees, and permits required shall be secured and paid for by the Contractor, unless otherwise indicated.

D. See Division 33 for site domestic water distribution and water meter requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for Plumbing and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, Piping Specialties for plumbing.

B. Insulating Fittings: Insulating unions shall be furnished and installed at all connections between dissimilar metals.

C. Valves: Each water service main, branch main and branch to a group of two or more fixtures shall be valved. Stop valves shall be as specified under fixtures.

D. Flexible Connections: If the Contractor uses a pipe material other than copper to connect to the City water main, provide mechanical joints at the connection point and also either a swing joint or expansion joint at a point 5 ft. outside the building to prevent failure of piping caused by differential settling of building and piping systems. The expansion joint material shall be suitable for domestic water usage and compatible with the sterilization chemicals.

3.02 STERILIZATION

A. All new water piping shall be charged with a chlorine solution containing not less than 50 PPM available chlorine. The solution shall remain in the piping for a period of 24 hours, during which time valves shall be opened and closed to permit a small flow of the solution. At the end of 24 hours, the solution shall be tested and must contain a residual of at least 5-10 PPM chlorine. The system shall then be drained and flushed to provide satisfactory potable water before final connection is made to the existing distribution system.

B. The Contractor shall submit a sample of the water, after sterilization and flushing for testing by an approved laboratory. A copy of the acceptable test report shall be submitted to the Architect prior to substantial completion.

3.03 BACKFLOW PROTECTION

A. Protection: All plumbing fixtures, faucets with hose connections, and all other equipment having plumbing connections shall have their water supplies protected against back-siphonage.

B. Testing: Arrange for testing backflow devices as required by the local health authorities.

3.04 TESTS

A. All water piping, hot and cold, shall be made tight under a hydrostatic test pressure of 150 lbs. per square inch and maintained without pressure loss for a minimum of four (4) hours. No caulking of joints will be permitted. Any joint found to leak under this test shall be broken, remade and a new test applied.

END OF SECTION

SECTION 22 1123 - FACILITY NATURAL GAS SYSTEM

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions and Supplemental General Conditions.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.
B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.
C. Section 22 0505, Piping Specialties for Plumbing.
D. Section 22 0523, Valves for Plumbing.

1.03 SCOPE

A. Complete building natural gas piping system including meters, regulators, and miscellaneous accessories. This section shall include all work within the building and to a point approximately 5'-0" outside the building, or as otherwise indicated.

PART 2 PRODUCTS

2.01 PIPING

A. Above ground pipe used for the installation, extension, alteration, and/or repair of any gas piping system shall be black steel pipe ASTM A53 Grade A or B, ERW or BW, standard wall, Schedule 40.
B. All underground gas piping shall be steel or polyethylene plastic piping as specified in Section 22 0523, Valves for Plumbing. All underground steel piping and fittings shall be protected from corrosion by approved coatings or wrapping materials as specified in Section 22 0504, Pipe and Pipe Fittings for Plumbing, and Section 22 6801, Outside Utilities, Plumbing.]

2.02 FITTINGS

A. Fittings for steel piping 2" and smaller shall be either screwed or welded. Screwed fittings shall be Class 150 standard black malleable iron conforming to ANSI B16.3. Weld fittings

shall be either standard weight steel butt-weld fittings conforming to ANSI B16.9, or forged steel socket-weld fittings, 2000 pound Schedule 40 conforming to ANSI B16.11.

B. Fittings for steel piping 2-1/2" and larger shall be standard weight steel butt-weld fittings conforming to ANSI B16.9.

2.03 FLANGES

A. Flanges for steel piping system shall be forged steel, weld neck, or slip-on, 1/16" raised face Class 150 flanges conforming to ANSI B16.5.

B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.

C. Where specifically required by the application, black cast iron Class 125 standard threaded plain face companion flanges may be utilized for flanged connections in threaded piping systems.

D. Gaskets shall be 1/16" thick full face non-asbestos material suitable for the temperatures and pressure application.

E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.04 VALVES

A. Valves shall be as specified in Section 22 0523, Valves for Plumbing.

B. Valves used in conjunction with gas piping shall be approved for the required service.

2.05 GAS METERS

A. Natural gas meters shall be furnished and installed by the natural gas utility company, unless otherwise indicated on the drawings. All required permits and fees shall be secured and paid for by the Contractor in accordance with Section 22 0500. Gas meter shall be the type and capacity required for the application and shall be located as indicated on the drawings and in accordance with utility company requirements and applicable codes and ordinances.

B. Division 22, Section 22 6801, for natural gas meters.

C. Natural gas meters shall be furnished and installed by the Contractor in accordance with the information shown on the drawings and in the plumbing equipment and fixture schedule on the drawings.

D. All natural gas meters shall be preceded by a main gas supply shut-off valve serviceable and accessible outside the building.

2.06 NATURAL GAS REGULATOR

A. Natural gas regulator shall be furnished and installed with the gas meter by the utility company, set for the required gas leaving pressure shown on the drawings.

B. Natural gas appliance and equipment regulators for all gas fired equipment furnished and installed under Division 23 shall be furnished by the equipment manufacturer or supplier and sized for the system inlet pressure and the required appliance operating pressure.

C. Division 22, Section 22 6801, for natural gas meter and regulator.

D. Natural gas regulators, as specified and shown on the drawings, shall be furnished and installed by the Contractor.

2.07 PIPING SUPPORTS

A. Natural gas piping installed on the building roof shall be supported by means of piping supports, especially designed to absorb thermal expansion and contraction of piping installed on built up and single ply membrane roofs. Wood blocks are not acceptable. Four inch and smaller gas piping shall be mounted on Erico Pyramid pipe supports or equivalent, pipe supports with a total weight not to exceed 100 pounds per pipe stand. Larger piping, and all piping requiring roller bearing action for pipe expansion, shall be mounted on Erico Pyramid RPS-H or equivalent, with a total weight not to exceed 1500 pounds per pipe collar support. Pipe support spacing shall be as recommended by manufacturer and as required by Code.

B. Piping hangers and supports shall be in accordance with Section 22 0504, Pipe and Pipe Fittings for Plumbing.

2.08 PAINTING

A. All natural gas piping installed outside the building exposed to the weather and/or exposed to view shall be field painted in accordance with the painting sections of this specification.

PART 3 EXECUTION

3.01 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for Plumbing, and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, Piping Specialties for Plumbing.

B. Installation of piping and equipment shall be in accordance with applicable codes and regulations, including Uniform Plumbing Code and Uniform Mechanical Code, and NFPA No. 54, National Fuel Gas code.

C. No gas piping shall be installed in or on the ground under any building or structure, and all exposed gas piping shall be at least 6-inches above grade. Ferrous gas piping installed underground in exterior locations shall be protected for corrosion as specified herein and in Section 22 0504, Pipe and Pipe Fittings for Plumbing.

D. Gas piping supplying the building or facility shall be provided with a shut-off valve located outside the building and readily accessible. Where gas piping supplies multiple buildings or facilities, each building shall be provided with a shut-off valve as described herein.

3.02 EQUIPMENT AND APPLIANCE CONNECTIONS

A. All gas fired equipment and appliances shall be connected to the gas piping system in an approved manner and shall be furnished with a shut-off valve installed ahead of the unit. Connections shall in no case be less than the unit inlet connection size and shall be rigidly connected, except as otherwise shown on the drawings and allowed by codes and regulations.

3.03 DRIPS

A. Accessible capped drip pockets shall be furnished at low points in piping system, connections to appliances and equipment, and other locations where condensation may tend to collect.

3.04 VENTS

A. All gas regulators and other required devices installed within the building shall be vented to the outside of the building in accordance with manufacturer's requirements, codes, and regulations.

3.05 TESTS

A. All gas piping shall be pressure tested using air, CO2, or nitrogen in accordance with the applicable codes and regulations, including Uniform Plumbing and Mechanical Code as adopted and interpreted by the City of Clovis and State of New Mexico and NFPA No. 54.

END OF SECTION

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions and Special Provisions.

B. Furnish and install all concrete, grout, and other required materials to fill all blockouts and/or sleeves left open for this Contractor's convenience or for the installation of this work.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Division 33 for Onsite Utilities Plumbing.

1.03 SCOPE

A. Complete soil, waste, and vent system, and associated miscellaneous accessories. This section shall include all work within the building to a point approximately 5'-0" outside the building, or as otherwise indicated.

B. Coordinate with Division 33 site utility drawings and specifications.

C. Plumbing equipment drains.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. General: Piping Materials listed below shall conform to the testing agency/standard specified. Pipe shall be marked with the manufacturer’s name, country of origin, pipe diameter and length, applicable ASTM standard and trademark of third party certifier. Third party certifier shall be accredited by ANSI. Pipe shall be manufactured by Tyler, Charlotte, New Age Casting, or approved equal.

B. Soil, waste and vent pipe and fittings below slab:

1. Hubless cast iron, conforming to ASTM A 888 and CISPI 301.

2. Service weight, hub-and-spigot cast iron, conforming to ASTM A 74.

3. Schedule 40, solid wall, polyvinyl chloride (PVC) with a cell class of 12454 or 12364 per ASTM D 1784, iron pipe size (IPS) conforming to ASTM 1785 and ASTM D 2665. Cast iron pipe and fittings shall be used on all waste piping subject to waste water temperatures that exceed 120° F.

C. Soil, waste and vent pipe and fittings above grade:

1. Hubless cast iron, conforming to ASTM A 888 and CISPI 301.

2. Service weight, hub-and-spigot cast iron, coated on both sides, conforming to ASTM A 74.

2.02 JOINTS

A. Hubless cast iron: Heavy duty, shielded, minimum (4) band couplings consisting of elastomeric gasket conforming to ASTM C 564 and 0.008" thick type 304 stainless steel shield.

B. Hub-and-spigot cast iron: Double seal compression type rubber gaskets conforming to ASTM C 564, with adhesive type lubricant, Tyler "LUBRI/FAST" or equivalent.

C. PVC: Two step primer/solvent cement procedure per ASTM D 2855. Adhesive primer shall conform to ASTM F 656 and solvent cement shall conform to ASTM D 2564.

2.03 PLUMBING EQUIPMENT DRAINS

A. Equipment drain lines shall be either Schedule 40 galvanized steel pipe with galvanized malleable iron fittings or Type L copper tubing with wrought solder fittings. Provide a dielectric union at all connections between ferrous to copper materials.

2.04 DRAINS

A. Floor drains, floor sinks, and interceptors shall be Josam, Rockford, Jay R. Smith, Wade, Watts, Zurn, Mifab, or equivalent, as specified on the drawings, and compatible with the required piping systems.

B. Non water-based trap seal maintenance devices by Jay R. Smith Mfg. Co., Liquidbreaker – The Green Drain, SureSeal, and TrapGuard as specified on the drawings are approved.

2.05 TRAPS AND TAILPIECES

A. Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel, not less than 20 gauge and without cleanout. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level and swivel joints below the discharge level, metal to metal or metal to plastic type as required for the application. Outlet shall be threaded or socket for solder joint connection as required by the application. Tailpiece shall be copper-alloy to match P-trap. Furnish cast brass wall escutcheon at waste penetration through walls. P-traps, tailpieces, escutcheon, and all piping for above floor exposed installations, including installation within cabinets and casework shall be chrome plated. Underground P-traps shall be coated cast iron or plastic as required by the application.

B. Traps and associated trim shall be furnished by the plumbing fixture manufacturer as specified in Section 22 4000 and in the Fixture Schedule on the drawings, or shall be as manufactured by Dearborn, EBC, McGuire, T & S Brass, or equivalent.

C. Traps for acid resistant piping systems shall be compatible material for required piping system.

2.06 CLEANOUTS

A. Cleanouts shall be as manufactured by Zurn, Jay R. Smith, Watts, Wade, or Josam, and shall be of the same size as the pipe, except that cleanout plugs larger than 4 inches will not be required. Cleanouts installed in connection with cast iron soil pipe shall consist of a long sweep, quarter-bend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. A standard cleanout fitting, Zurn No. ZN-1400-ZB, with polished bronze top shall be caulked into the hub of the fitting and finished flush with the floor. Heavy duty cleanouts shall be Zurn Z-1474, with integral anchor flanges. Where cleanouts in connection with threaded pipe are shown and are accessible, they shall be cast iron drainage T-pattern, 90 degree branch fittings with square head brass screw plugs of the same size as the pipe up to and including 4 inches. Wall cleanouts in finished areas shall be Zurn No. Z-1460-8 with polished stainless steel or chrome plated metal cover.

B. Cleanouts for acid resistant piping system shall be compatible material for the required piping system.

C. Install cover flush with grade (outside) to avoid tripping hazard.

2.07 MANHOLES

A. See Division 33 for manholes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for plumbing, and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, Piping Specialties.

B. All soil, waste, and vent piping shall be properly graded and installed in strict accordance with all applicable codes and requirements.

C. Make all changes in direction of drainage piping by use of 45 degree wyes, long turn tee wyes, long sweep quarter bends, sixth, eighth or sixteenth bends. Short turn sanitary tees permissible on horizontal to vertical where space conditions require.

3.02 FLASHINGS

A. Flashing for piping through built-up roofing with lead flashing, weight of not less than four pounds per square foot, extending at least 12" in all directions under roofing and up pipe. Cap flash pipe and turn down inside 1" approximately. Run all pipes extending through roof prior to roof installation. Flashing shall be two-piece type, base and cap flashing.

B. Vinyl Flashing: As an option to lead flashing in vents through roof, the Contractor may use vinyl flashing, 20 mil thickness, ASTM C689-62 tear strength, 0.14 #/Ft. equal to Pasco Manufacturing Co., or equivalent. The flashing shall be installed in accordance with the manufacturer's recommendations.

C. Flash piping through the membrane roofing systems with premolded pipe seal elastomeric flashing and sealants that are compatible with EPDM single ply membrane. The flashing material and installation procedure shall be in accordance with the roofing manufacturer's recommendations.

3.03 DRAINS

A. All floor drains, and floor sinks shall be installed with grates square with building lines and with the top of grates installed level with adjacent finished floor.

B. The Contractor shall extend drain lines from all equipment requiring drainage, relief valves, and drain pans to the nearest floor drain or floor sink, and shall terminate indirectly with a minimum clearance of one (1) inch or as otherwise required by applicable codes and standards. Relief valve drain lines shall be extended to the nearest floor drain and shall be equal in size to relief valve outlet port.

3.04 TESTS

A. The sanitary soil waste and vent system and condensate drain system shall be tested by filling system with water. System shall remain filled with no loss of water for a minimum of 2 hours. The system water test shall be applied to the drainage and vent systems either in its entirety or in sections. Preliminary testing shall be accomplished as necessary prior to final test.

B. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than ten (10) feet of water. In testing successive sections, at least the upper ten (10) feet of the next preceding section shall be tested, so that no joint or pipe in the building (except the uppermost ten feet) of the system shall have been submitted to a test of less than a ten (10) foot head of water. The system shall then be tight at all points.

END OF SECTION

SECTION 22 4000 - PLUMBING FIXTURES AND TRIM

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 1100, Domestic Water Piping.

D. Section 22 1316, Sanitary Waste and Vent Piping.

PART 2 PRODUCTS

2.01 FIXTURES AND EQUIPMENT

A. Vitreous china and enameled cast iron fixtures by American Standard, Kohler, Sloan, Zurn, Mansfield, Toto, or equivalent as listed and described in the plumbing fixture schedule on the drawings. All vitreous china and enameled cast iron fixtures shall be white, unless otherwise indicated on the drawings. The material used for plumbing fixtures shall be of non-absorptive, acid-resistant vitreous china, enameled cast iron or stainless steel, and free from all imperfections. Each water service main, branch main, riser and branch to a group of fixtures shall be valved or as otherwise shown on the drawings to provide more stringent requirements. Stop valves shall be provided at each fixture. One piece chrome plated escutcheons shall be installed on all water piping and trap connections at walls or base cabinets. All exposed connecting piping and material shall be

chrome plated.

B. Handicap accessible lavatories and counter mounted sinks shall have exposed supply and waste services insulated with rigid, molded insulation kits as manufactured by T.C.I. "Skal-Gard", Brocar "Trap Wrap", True-Bro "Handi Lav-Guard", McGuire "Prowrap", or equivalent. Provide off-set tail piece fittings on all handicap accessible laboratories and sinks as required.

C. Flush valves shall be low water consumption type as specified on drawings. Valves shall be diaphragm or piston type, with metal oscillating non-hold open handle, screw driver back check angle stop assembly with cap, adjustable tailpiece, vacuum breaker flush connection, and spud couplings as required for wall and fixture rough-in. Exposed flush valves shall be fully chrome plated, with chrome plated supply pipe cover. Flush valves shall be American Standard, Delany, Delta, Sloan Royal, Zurn, , Toto, or equivalent.

D. Closet seats shall be furnished for water closets as specified on the Plumbing Fixture Schedule on the drawings. Closet seats shall be white unless otherwise required to match water closet. All closet seats shall be of smooth non-absorbent material and shall be properly sized for the water closet bowl type. All closet seats for fixtures for public use shall be open-front type without cover. Water closet seats provided for handicapped fixtures shall meet all handicapped requirements. Hinges, posts, nuts, and pintles shall be of a 300 series stainless steel construction. Water closet seats shall be furnished by the plumbing fixture manufacturer as specified on the Fixture Schedule on the drawings, or shall be as manufactured by Bemis, Beneke, Centoco, Church, Jones Stephens, Olsonite, Sperzel, or equivalent.

E. Floor mounted mop sinks shall be as specified on the Plumbing Fixture Schedule on the drawings, molded stone or terrazzo, size and arrangement as shown on the drawings, as manufactured by Acorn, Centoco, Designer’s Choice, Fiat, Mustee, Stern-Williams, Zurn, or equivalent. All mop sink faucets shall be equipped with inlet checkstops.

F. Stainless steel sinks shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Kohler, American Standard, Elkay, Just, Advance Tabco, Moen, Intersan, or equivalent. Countertop sinks indicated within the Architectural drawings to be handicap-compliant shall have an off-centered drain opening and a maximum sink depth of 7-inches. All sink basins shall have a center-rear outlet unless noted otherwise.

G. Electric water coolers (EWC) and drinking fountains shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Acorn Aqua, Elkay, Guardian, Halsey, Haws, Murdock, Oasis, Sunroc, Taylor or equivalent.

H. Hose bibbs and wall hydrants shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Zurn, Jay R. Smith, Wade, Woodford, Acorn, Chicago, T&S Brass, Watts, Prier, or equivalent. Handles, if specified shall be constructed of metal or brass and finished to match valve unit.

I. Shower valves and mixing valves shall be as specified on the Plumbing Fixture Schedule on the drawings, and as manufactured by Powers, Leonard, Lawler, Speakman, Symmons, Bradley, or equivalent.

J. Emergency fixtures including showers and eyewash shall be as specified on the Plumbing Fixture Schedule on the drawing and as manufactured by Bradley, Chicago, Haws, Speakman, Western, Guardian, Acorn Safety, or equivalent.

2.02 FAUCETS

A. Plumbing fixture faucets shall be brass construction and fully chrome plated, unless special finish is specified on the Plumbing Fixture Schedule on the drawings. Faucets shall be furnished complete with all accessories required for the necessary application, including aerators, handles, spouts, and operating cartridges. Contractor shall coordinate exact faucet requirements with required fixture drilling and water and waste rough-in. Faucets for handicapped fixtures shall meet all handicapped and ADA requirements, including a maximum of five (5) pounds of force to activate controls and adjustable metering faucet water flow duration of ten (10) seconds, minimum. Single hole faucets shall have anti-clocking pin to prevent rotation of valve body.

B. Plumbing fixture faucets shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as manufactured by Chicago, Delta, Moen, Speakman, T&S Brass, Zurn, or equivalent, and shall be commercial grade.

2.03 PLUMBING FIXTURE TRIM

A. Plumbing fixture trim including P-traps, supplies, and strainers shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as furnished by Chicago, Brass Craft, McGuire, T&S Brass, EBC, Zurn, or equivalent.

B. Unless otherwise specified, traps shall be copper-alloy adjustable tube-type with slip joint inlet and swivel, not less than 20 gauge and without cleanout. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level and swivel joints below the discharge level, metal-

to-metal or metal-to-plastic type as required for the application. Outlet shall be threaded or socket for solder joint connection as required by the application. Tailpiece shall be copper-alloy, offset style, to match P-trap. Furnish brass or copper wall escutcheon at waste penetration through walls. P-traps, tailpieces, escutcheon, and all piping for above floor exposed installations, including installation within cabinets and casework shall be chrome plated.

C. Fixture supplies, strainers, and trim shall be brass construction. Supplies shall be commercial grade, quarter-turn all brass ball valves, plastic stems and handles are not acceptable. Furnish supply with loose key unless otherwise specified. Supply pipe shall be 3/8" O.D., with smooth (non-corrugated) flexible copper riser and wall escutcheon. Supply assembly shall be completely chrome plated for all exposed installations, including installation within cabinets and casework. Strainers and other miscellaneous fixture trim shall be furnished as required for the proper installation and shall be chrome plated to match faucets, unless special finish is required.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall provide all necessary supports and connection materials and trim for plumbing fixtures as required to assure a complete properly installed and operating system. Installation shall be in accordance with manufacturer's recommendations and with International Building Code and Uniform Plumbing Code requirements. The Contractor shall caulk fixtures to the adjacent wall, floor and countertop construction with non-shrink, mildew resistance caulking material.

B. Fixture mounting height shall conform to the ADA Accessibility Requirements and coordinated with the Architectural drawings.

1. ADA required Water Closet shall be mounted with top of seat 17” – 19” above finished floor.
2. ADA required Urinal shall be mounted at a maximum of 17” top of rim to finished floor.
3. ADA required Lavatory to be mounted with the rim or counter surface no higher than 34” above finished floor.
4. ADA required shower controls shall be located from 38” minimum to 48” maximum height above the shower floor.

5. ADA required Bathtub controls shall be located maximum of 48” above bottom of tub surface.
6. ADA required Sinks shall be mounted with counter or rim no higher than 34” above finished floor.
7. ADA required Drinking Fountains or Water Coolers spouts shall be no higher than 36” measured from the floor or ground surface to the spout outlet.

3.02 EQUIPMENT/FIXTURE SUPPORT

A. Furnish and install all "back-up" materials for fixtures and accessories, or as otherwise required by the equipment schedule to properly support and provide a sturdy installation.

3.03 FIXTURE CARRIERS

A. Fixture carriers shall be provided for all wall hung plumbing fixtures, including water closets, urinals, lavatories, sinks, etc., as manufactured by Josam, Jay R. Smith, Watts, Wade, Zurn, MiFab, or equivalent. Carriers shall be bolted to the floor using all of the support bolts recommended by the manufacturer. Where the water closet nipple and studs extend beyond the maximum carrier recommended length, provide additional carrier support as recommended by manufacturer. Water closet carriers shall be horizontal or vertical, single or back-to-back units as required for the fixture installation and piping arrangement, and shall be adjustable.

B. Single water closet carriers shall have factory installed rear hold down lugs and anchor foot to provide cantilever support.

C. Wall hung urinals shall be provided with floor mounted fixture carrier complete with upper and lower fixture support plates as required to match fixture installation requirements.

D. Wall hung lavatories and sinks shall be provided with floor mounted concealed arm type chair carriers, single or double (back-to-back) units as required for the fixture installation and arrangement.

E. Contractor shall be responsible to provide the proper arrangement and selection of fixture carriers required for fully concealed installation in the available plumbing chase and/or wall construction.

3.04 FIELD MEASUREMENTS AND COORDINATION

A. Exact location and rough-in requirements shall be carefully coordinated. Contractor shall refer to drawings and specifications, and shall check manufacturer's data, shop drawings and rough-in drawing submitted under Division 22 and other Divisions of this specification and make all field

measurements to the extent necessary to ensure his understanding of the work required to provide for complete rough-in installation.

3.05 CLEANING

A. All fixtures shall be thoroughly cleaned before final acceptance of the work.

END OF SECTION

SECTION 23 0500 - COMMON WORK REQUIREMENTS FOR HVAC

PART 1 GENERAL

1.01 SCOPE OF WORK

A. See General Conditions and Supplemental General Conditions.

B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this Section and all subsequent sections of this Division and form a part of the contract.

1.02 INDEX OF SPEC SECTIONS FOR THIS DIVISION

A. 23 0500 Common Work Requirements for HVAC

B. 23 0504 Pipe and Pipe Fittings

C. 23 0505 Piping Specialties

D. 23 0523 Valves

E. 23 0549 HVAC and Electrical Installation Coordination

F. 23 0593 Testing, Adjusting and Balancing of Mechanical Systems

G. 23 0700 Mechanical Systems Insulation

H. 23 0900 Facility Management System for DDC Controls

I. 23 2313 Refrigerant Piping System and Equipment

J. 23 3000 Air Tempering System and Equipment

1.03 DEFINITIONS

A. General: Terms will have meanings as defined in Webster’s Eleventh New Collegiate Dictionary except as noted below.

B. Entities

1. Owner: Curry County
2. Architect: Formative Architects
3. Engineer: Bridgers & Paxton
4. Owner's Representative: The Owner will designate his representative after bid. The abbreviation “OR” may be used throughout these specifications to refer to the Owner’s Representative.

5. Owner's Agents: The Architect, Engineer, and others authorized to act on behalf of the Owner.

C. Actions

1. Supply: Procure and deliver to the site with all features as specified, required per code, and as required for proper installation. Include submittals, O&M manuals, operator instructions, and warranty.
2. Install: Set in place in accordance with manufacturer's instructions, contract documents, and applicable codes and standards. Coordinate the installation with other disciplines, start, and demonstrate proper operation.
3. Furnish: Supply and install.
4. Provide: Supply and install.
5. Accepted: By the Owner’s Representative except as noted.
6. Approved: By the Owner’s Representative except as noted.
7. Review: By the Engineer except as noted.

D. Locations

1. Buried: Surrounded by soil or other material, either beneath the building or exterior to the building.
2. Exterior: Exposed to rain or snow. Examples include rooftop locations, spaces around cooling towers, pipe racks, etc.
3. Interior: Not exterior or buried. Examples include not only spaces within the heated envelope of the building, but also unheated attics, covered loading docks in which spaces are protected from rain and snow, utility tunnels, sheds, etc.
4. Finished Spaces: Interior spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated attics, spaces above ceilings, crawlspaces, and tunnels.
5. Exposed: Exposed to view. Examples include finished spaces mechanical equipment rooms, rooftops, etc.
6. Concealed: Not Exposed.

E. Other Definitions:

1. 24/7: 24 Hr/day, 7 days per week, year-round.
2. AHJ: Authorities having jurisdiction. The authorities having jurisdiction over this project are established by statute, and include governmentally designated building

departments, the fire marshal, fire departments, etc. No attempt is made to list all such entities here; a qualified Contractor is expected to know and coordinate with the various authorities having jurisdiction.

3. FMS: Facility Management System
4. Local: Based no further from the job site than the Engineer is. For example, where the specifications call for a local factory authorized service agent, then on a daily basis that agent must be based in an office or warehouse located no further from the project site than the Engineer's office.
5. OAE: Or approved equal.

1.04 CODES AND PERMITS

A. Perform all work in accordance with the 2021 International Building Code, 2018 International Energy Conservation Code, the 2021 Uniform Plumbing Code, and the 2021 Uniform Mechanical Code, as adopted and interpreted by the State of New Mexico and City of Albuqerque and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. Contractor shall hold and save the Owner and his agents free and harmless from liability of any nature or kind arising from the Contractor's failure to comply with codes and ordinances.

B. Secure and pay for all permits necessary for performance of the work, including utility connections, extensions, meter pits and meter sets and tap fees for water, storm sewer, sanitary sewer and natural gas, unless otherwise specified herein.

C. Comply with the requirements of, and the recommendations of:

1. Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances
2. National Electrical Manufacturer's Association
3. National Electrical Code
4. Underwriters Laboratories
5. American National Standards Institute
6. American Society for Testing Materials
7. Local utility companies

8. National Fire Protection Association
9. ASME Boiler and Pressure Vessel Codes
10. Occupational Safety and Health Administration
11. International Fire Code
12. Midwest Insulation Contractors' Association (MICA)
13. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
14. American Society of Sanitary Engineering
15. American Gas Association

1.05 PRIOR APPROVAL

A. Refer to Division 1 for Prior Approval Requirements.

B. Prior approval (approval prior to bid) of alternate mechanical equipment suppliers and service providers is not required. Please do not request prior approval. Alternate manufacturers and service providers may be submitted after bid in accordance with the submittal process provided they meet or exceed the specifications and the indicated design intent.

1.06 DOCUMENT MANAGEMENT

A. Contractor is encouraged to use a web-based document management system for RFIs and submittals. If used, Contractor shall provide and pay for licenses and training for the engineer's project personnel. The section below describes procedures for handling submittals if a web-based document management system is not used. If a web-based system is used, the procedures below shall be modified as appropriate.

1.07 SUBMITTALS

A. See Division 1 and individual specification sections within this division for additional submittal requirements.

B. Prior to purchasing materials, equipment and services, submit descriptive literature for review.

C. See Division 1 and individual specification sections within this division for additional submission requirements. The following describes general submittal procedures. More specific procedures will be established after award. Whenever electronic files are to be submitted, e-mail them through normal channels. But if files are too large to e-mail, then submit them in quantities as described below.

1. Submittal Schedule: Along with the first item submitted for review, include a schedule listing all items to be submitted and an approximate date for each submittal. Submit this schedule in both hard copy and electronic form (Microsoft Excel). Normal review time will be 10 working days or as indicated in Division 1. Schedule should identify any submittals for which expedited review is requested. Update this schedule and resubmit it monthly (by e-mail) for information.
2. Include the following information with each submittal:
    a. Cover sheet identifying the project name, contractor, architect, engineer, and items included. Indicate symbol numbers, spec section, etc.
    b. A blank space large enough to accept a review stamp.
    c. Performance under the specified conditions
    d. Cover sheet shall clearly identify and **HIGHLIGHT** any ways in which the submitted materials, equipment or services deviate from the Specifications.
3. Quantities:
    a. Submit electronically as a searchable PDF document. Include electronic bookmarks for submittals that contain multiple items for review.
4. Engineer will review one original submittal and one resubmittal for each item. If the Contractor fails to provide the required data or acceptable items with his second submittal, he will be charged for the Engineer's costs for the third and subsequent reviews.
5. Required Information: Submit information to allow the Engineer to easily determine whether the submitted components comply with the general design intent. Include relevant descriptions of materials, features, performance, quality and dimensions. Cross out all features, options and accessories which will not be provided. It is assumed that all specified, indicated and/or required features will be provided unless specifically noted otherwise.
6. Where specifications require a local factory authorized service agent, submit the name, address, and contact information for this agent. Include this information also in the O&M Manual.

D. Review of Submittals: Engineer will review submittals for general conformance with the design intent.
    1. Review of a separate item as such will not indicate review of the assembly in which the

item functions.

2. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work.
3. Review will not relieve the Contractor of responsibility to comply with the contract requirements, or responsibility to ensure that equipment fits within the allotted space with required clearances for equipment operation, service and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC).
4. For commodity type items (plumbing fixtures, terminal units, registers, diffusers, etc), Engineer will review submittals for type only. Contractor to coordinate sizes and quantities.
5. Actions: Engineer will return submittals with one of the following actions:

   NO EXCEPTIONS TAKEN Contractor may proceed with the work as submitted

   EXCEPTIONS AS NOTED Contractor may proceed with the work and without resubmittal provided he complies with all exceptions noted in the submittal, and so states in a letter

   REVISE AND RESUBMIT Resubmit in accordance with the indicated comments

   REJECTED Resubmit in accordance with the contract documents

   RETURNED WITHOUT ACTION This submittal has not been reviewed, and therefore the Engineer is returning it with no direction to the Contractor.

E. Substitutions:

1. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or if any work is installed in a manner which is not in conformance with the requirements of this specification and for which the Contractor has not received written authorization, remove such unauthorized work and install work in accordance with the contract documents at no change in contract amount.
2. Authorized Substitutions: Provide all accessories and features as required and coordinate substitutions with other disciplines. Bear any extra expenses resulting from the use of substitutions which affect adjoining or related work required in this division or other

divisions of the work.

3. If the Contractor substitutes equipment for that indicated on the drawings, he shall prepare a 1/4 inch = 1foot installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will properly fit within the space with adequate clearance for maintenance and replacement. Submit this drawing for review.

F. Schedule: Submit all submittals in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time. Be aware that there is risk in ordering components, fabricating work, and/or installing work prior to review. If the Contractor proceeds prior to review, and then the review comments required modifications to work which has begun or has been completed, then Contractor must comply with the review comments at no change in contract amount or schedule.

G. Shop Drawings

1. Submit shop drawings for
   a. Mechanical equipment rooms and other spaces housing air handling equipment, heat transfer equipment, fluid handling equipment, machinery, etc.
   b. Complete supply, return, and exhaust ductwork systems, both exposed and concealed.
   c. Piping for HVAC, plumbing, and fire protection systems, both exposed and concealed.
2. Show the location and elevation of all equipment, ductwork and piping, as well as openings through slabs and walls. Include plans, elevations and sections as appropriate. Clearly show the manner in which the systems fit into the available space and relate to each other and to the building elements. Indicate required sleeves and openings in general construction elements. Indicate required clearances for operation, maintenance and replacement of operating devices and equipment. Drawings shall be of appropriate scale to facilitate coordination and understanding, but not smaller than 1/4 inch scale for floor plans and 1/4 inch scale for equipment rooms and chases.
3. Conflicts: The engineer has endeavored to work out conflicts in areas where the design is congested, but has not tried to show all required offsets to coordinate with the building construction and building systems, particularly in less congested areas. The intent is that

the Contractor coordinate the design of the piping and ductwork distribution systems with the building construction and the various building systems, particularly in less congested areas. Provide experienced designers to perform such services and prepare shop drawings. Exercise good design practice in working out conflicts without compromising system operation or maintenance. Provide fittings, offsets, etc., as required. Contractor shall include this design effort and include the labor and materials for such fittings and offsets in his base bid. Except in extremely unusual circumstances, no additional costs will be allowed related to working out conflicts. Coordinate with other disciplines as required. Identify on the shop drawings those areas where redesign was necessary to resolve design conflicts.

a. In the event that the Contractor desires direction in resolving a design conflict or desires prior approval of a recommended approach to resolving a conflict, submit an RFI which identifies the conflict and suggests a recommended solution.

b. In resolving conflicts, gravity lines and larger distribution mains will generally have priority over pressurized lines and smaller lines as follows:

Plumbing waste and vent lines
Roof drains
Steam and condensate piping
Supply, return and exhaust ductwork
Fire sprinkler mains
Heating hot water and chilled water piping
Domestic hot and cold water
Fire sprinkler branch piping and sprinkler runouts
Pneumatic control piping
Miscellaneous special piping systems

4. Use of Engineer's CADD Database or BIM Model: The Engineer will provide the Contractor electronic files of the Engineer's CADD Database or BIM Model of the design documents if the Contractor completes and submits the License Agreement form included at the end of this spec section. These files show the general design intent and may be used as a starting point for the Contractor to begin his shop drawings and coordination effort, but the Contractor should not use them as a basis for ordering or fabrication. The normal submittal process still applies, regardless whether the Contractor

elects to use the Engineer's CADD Database or BIM Model.

H. Submittals Required under this Specification Section:

1. Electrical Components: Motors, Motor Controllers, and Variable Speed Drives
2. Identification: Products used to identify equipment, ductwork, valves, piping, and control devices.
3. General Construction Components: Roof Curbs & Access doors.

1.08 MISCELLANEOUS PROVISIONS

A. Qualifications

1. All mechanics shall be skilled in their respective trade.
2. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

B. Regulated Materials: Comply with all state, local and federal regulations regarding the storage, handling or disposal of oils, lubricants, cleaning agents, refrigerants, other liquids and gases, and hazardous materials.

C. Factory Identification: Provide all materials and equipment with labels sufficient to show compliance with these specifications and the performance requirements indicated on the drawings. All equipment shall carry a permanent label installed by the manufacturer stating that the equipment complies with ASHRAE/IESNA Std. 90.1.

D. Hazardous Conditions: Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

E. Hazard Signs

1. Provide a sign reading, "Hazardous Area - Authorized Personnel Only" on the doors to all equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments.
2. Provide a sign reading, "Confined Space - Entry by authorized personnel only by permit" for all confined spaces. Confined spaces shall be as designated by OSHA Standard 1910.146. This generally means a space that:
   a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
   b. Has limited or restricted means for entry or exit (for example, tanks, vessels,

storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and

c. Is not designed for continuous employee occupancy.

3. Survey the final premises to determine where any potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.09 GUARANTEE-WARRANTY

A. See Division 1 for additional information on warranties. Warranties shall run for one year from substantial completion unless indicated otherwise.

PART 2 PRODUCTS

2.01 PRODUCT GENERAL REQUIREMENTS

A. General: Products supplied under Division 23 shall comply with the following except as noted elsewhere.

B. Products shall be new; shall be the product of manufacturers regularly engaged in the production of plumbing, heating, ventilating, air conditioning, and control system equipment; and shall be the manufacturer's latest design. Specs and equipment schedules establish expectations regarding standard of quality and operating intent.

C. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

D. Products shall be suitable for the conditions under which they are installed and operated. Prior to or during the submittal phase advise the Owner’s representative and the Engineer in writing regarding any concerns about the suitability of the specified products for the intended application or service. Request clarification if any question exists regarding the design intent.

E. Performance Ratings: Unless otherwise noted, all scheduled equipment performance is based on an elevation of 4600 feet above sea level. Adjust manufacturer's ratings accordingly.

F. Structural Soundness: Products shall have structural integrity appropriate to the component and its application. Bases shall be rigid and shall keep all components in proper alignment. Structural integrity shall be adequate for both rigging and final installation. Components shall not be loose, rattle, or vibrate unnecessarily in their final installed condition.

G. Corrosion Resistance: Equipment shall be of materials inherently corrosion resistant, or shall be finished with a corrosion-resistant finish suitable for the location in which the equipment is installed.

H. Touch-up: If the factory finish of any component is damaged prior to substantial completion, touch up to original condition per manufacturer's recommendations.

I. Equipment Access Doors or Panels: Provide access doors and panels within equipment to ensure good access to all components requiring inspection, service or maintenance. Provide appropriate hardware. Equipment installed outdoors shall be weather-tight.

J. Fans: Statically and dynamically balanced, shaft first critical speed shall be above operating speed at design conditions.

K. Bearings: Grease lubricated or permanently lubricated.

L. V-Belt Drives: All components sized for 150% of motor HP, multiple belts shall be matched, fixed sheaves for motors 20 Hp and larger, adjustable sheaves for lower HP motors, all safety components for OSHA compliance (e.g., belt guard or other safety provisions) motor mounted on adjustable base. Provide a replacement sheave for each fixed sheave after T&B is complete. Include belt data in O&M manual. Gates Rubber Co, OAE.

1. Belt Guards: Rigidly constructed and attached, removable, galvanized steel, expanded mesh. Design to provide ready access to bearings.

M. Couplings: Provide coupling guard.

N. Motors and VFDs: See requirements described elsewhere in this spec section.

O. Drive Lines (starter or VFD, motor, coupling and shaft or v-belt drive and pulleys, and driven equipment): Coordinate with all suppliers and ensure all components are compatible to work as a system.

P. Coils: ARI rated, copper tubes mechanically expanded into aluminum fins, galvanized steel casing, drainable, pressure tested to 150% of working pressure but not less than 300 psi.

Q. Cooling Coil Drain Pans: Provide for all cooling coils, galvanized or stainless steel, double pitched with piped outlet. For units with more than one coil stacked, provide intermediate drain pans piped to the main drain pan.

R. Gas Burners: Natural gas fired, performance based on gas at 1000 Btu/SCF HHV but suitable for use with gas at 900 – 1050 Btu/SCF and 7 – 11 inches water column, factory installed and pressure tested gas train, all necessary safety and operating controls.

S. Filter Frames: Galvanized steel, provide wherever filters are specified.

T. Electrical & Controls: Except where specifically noted, electric service to each component listed on the equipment schedules will be through a single electrical feed at the voltage indicated on the equipment schedules. Include all components, cabling and conduits to distribute power to all components which are factory supplied and mounted. Provide transformer(s) if required to serve unit-mounted components requiring electric service at voltages different from the main electric service, including controls components. Provide secondary overcurrent protection. Provide terminal strips for field-installed control wiring. Provide unit-mounted, unit-specific wiring diagrams on durable paper, attached to inside of control panel door or otherwise affixed to the unit. All electrical components shall be UL Listed or Recognized. All factory-installed electrical work shall comply with the NEC unless the overall unit is listed by an organization acceptable to the AHJ, and listed to a standard acceptable to the AHJ.

1. Where equipment includes an LCD or other, similar display for operator interface, display all information in English. Displays should be readily understandable and should not require the user to look up display codes in a reference manual.
2. Provide battery backup to retain all memory and programming, and to keep all clock-related functions powered through a 1-week power outage.
3. Controls interface with the FMS:
    a. Digital Inputs to FMS: 24V DC sourced from equipment.
    b. Digital Outputs from FMS: Equipment to have form C relays, max 250V DC, 2 A.
    c. Analog Inputs to FMS: 4-20 mA, 0-5V DC, or 0-10V DC sourced from equipment.
    d. Analog Outputs from FMS: 4-20 mA sourced from FMS.

2.02 ELECTRICAL COMPONENTS

A. General: Except as noted, all electrical products and equipment shall comply with the requirements of this section, whether field installed or factory installed. See “Product General Requirements” and “Installation General Requirements” in Parts 2 & 3 of this spec section for additional requirements.

B. Motors

1. General: Except as noted motors shall be horizontal, open drip-proof, 4-pole, 1750 RPM, rated per NEMA MG-1, with fabricated steel or cast iron casing, motor terminal box

adequately sized for conductors one-size larger than specified, SS nameplate per NEMA MG-1-20.60, connection diagram attached to motor, compression lugs for power feeds and ground conductor, grease lubricated sealed ball bearings or roller bearings with standard grease fitting zerk and relief tapping, factory lubricated, dynamically balanced to no more than 50% of the NEMA allowable vibration limits. For motors powering V-belt drives, provide a cast iron or steel base with slide rail and adjustable belt tension device. Install motors and equipment on foundations and align as required. 40 deg C rise and total temperature rise of 65 deg C ambient.

a. 3/4 hp and smaller: 115V, single phase, 60 Hz, split phase or permanent split capacitor (PSC), NEMA Type N or O, with built-in thermal overload protection.
    1) Multi-speed motors.

b. 1 hp and greater: 208 V, 3 phase, 60 Hz, squirrel cage induction type, NEMA design B, T-frame, with Class B or F insulation, lifting lugs, 150,000 hr L-10 bearings for direct-coupled applications, 50,000 hr L-10 bearings for belt-driven application with radial loads and pulley sizes per NEMA MG1-14.43. Service Factor: ODP motors shall be rated for 1.15 SF at 40^{o}C or 1.0 SF at 65^{o}C; TEFC motors shall be 1.0 SF.
    1) Two speed motors: Provide with two separate windings.
    2) Variable speed motors: Drive compatible per NEMA MG1-31, premium efficiency as specified below regardless of Hp, Class F insulation, minimum 5-year warranty.

2. Efficiency: Except as noted, motors shall be premium efficiency type, with nominal efficiencies not less than the following as per the Consortium on Energy Efficiency (CEE), and minimum power factor of 0.85:

	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
HP	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0	82.5	85.5	78.5
1.5	86.5	86.5	85.5	87.5	86.5	85.5
2	87.5	86.5	86.5	88.5	86.5	86.5
3	89.5	89.5	86.5	89.5	89.5	88.5
5	89.5	89.5	89.5	89.5	89.5	89.5
7.5	91.7	91.0	89.5	91.7	91.7	91.0
10	91.7	91.7	90.2	91.7	91.7	91.7
15	92.4	93.0	91.0	92.4	92.4	91.7
20	92.4	93.0	92.4	92.4	93.0	92.4
25	93.0	93.6	93.0	93.0	93.6	93.0
30	93.6	94.1	93.0	93.6	93.6	93.0
40	94.1	94.1	93.6	94.1	94.1	93.6
50	94.1	94.5	93.6	94.1	94.5	94.1
60	95.0	95.0	94.1	94.5	95.0	94.1
75	95.0	95.0	94.5	95.0	95.4	94.5
100	95.0	95.4	94.5	95.4	95.4	95.0
125	95.4	95.4	95.0	95.4	95.4	95.4
150	95.8	95.8	95.4	95.8	95.8	95.4
200	95.4	95.8	95.4	95.8	96.2	95.8

3. Approved Manufacturers: General Electric Energy Saver, Baldor Super-E, Marathon Series E, Reliance Electric XE, Westinghouse TEE II, Eaton/Cutler Hammer, Toshiba, Louis Allis, or approved equal.

4. If the Contractor proposes to furnish motors varying in horsepower and/or characteristics from those specified, he shall first submit his request for the change and shall then coordinate the change with all other parties (e.g. electrical contractor) and pay any costs associated with the change.

C. Motor Controllers

1. Single Phase Manual Starters to 1 Hp and 120-277 V: Cutler Hammer MS with indicating light.

2. 3-Phase: Full voltage, non-reversing, electro-mechanical, combination circuit breaker and motor controller, UL Listed, NEMA rated, 460V, 65,000 AIC, minimum 50 VA 24V controls transformer with secondary overcurrent protection, suitable for operation at -4°F to +149°F and specified voltage -15% to + 10%, adjustable solid state overloads initially set at Class 10, HOA switch, run indicator, two auxiliary contacts for remote monitoring of status, and enclosure for surface mounting. Cutler Hammer OAE.

a. Provide enclosure appropriate to the location:

1) NEMA-1 for indoor dry locations.
2) NEMA-3R for outdoors.
3) NEMA-4 for wet applications.
4) NEMA-12 for dusty locations.
5) Explosion-proof – where required.

b. Motor controllers factory mounted and wired on AC units, boilers, etc, may be definite purpose, and need not have all the features specified here.

2.03 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. Provide wiring and conduit as scheduled in Section 23 0549.

B. Coordinate with all disciplines to ensure that all necessary components of control work are included and fully understood.

2.04 IDENTIFICATION

A. Scope: Identify all equipment, ductwork, valves, piping, and control devices shown on the Drawings, identified in the equipment schedules, and indicated in these Specifications. Provide submittals for products and procedures used for identification.

B. Equipment: For all mechanical equipment supplied or installed under Division 23, provide an equipment identification tag or stencil unit number onto the equipment. Stencils shall be minimum 3-inch height, dark contrasting color, of a material suitable for the application.

1. For rooftop HVAC equipment, provide a permanently affixed, weather-resistant label to identify the areas served.

C. Valves: Provide each valve with a stamped metal tag secured to the valve. Tag shall indicate the valve number, service and function. Provide two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Drawings shall be neat and easily readable. Provide a typed valve chart, listing the valve number, size, location, function, normal operating position, for each valve. List valves by system, i.e., domestic cold water, hot water, chilled water, etc. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.

D. Ductwork: Identify ductwork at or near the fan with stenciled signs on insulated ductwork or engraved laminated plastic signs secured by rustproof screws on un-insulated ductwork. Sign shall identify air conditioning system or fan unit and area served.

E. Piping

1. Provide color-coded pipe labels indicating the service of the pipe and the direction of flow. Piping labels shall comply with ANSI Standard A13.1 regarding color coding and size of lettering. The following standardized color code scheme shall be used:
   a. Yellow - Hazardous Materials.
   b. Green - Liquid Materials of Inherently Low Hazard.
   c. Blue - Gaseous Materials of Inherently Low Hazard.
   d. Red - Fire Protection Materials.
2. Labels shall be semi-rigid plastic identification markers. Labels shall "span-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4 inch through 5 inches. Labels for piping 6 inches and larger shall be furnished with spring attachment at each end of label. "SETMARK" Type SNA, 3/4 inch through 5 inch size and Type STR, 6 inches and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.
3. Labels shall be vinyl material with permanent adhesive for application to clear dry pipe and/or insulation jacketing. Pressure sensitive pipe tape matching the background color of the label shall be placed over each end of the label and completely around the pipe.
4. For retrofit projects the system names shall match existing.
5. Attach pipe markers to lower quarter of the pipe on overhead horizontal runs and on the centerline of vertical piping where view is not obstructed.
6. Provide the following labels, with ANSI/OSHA color and banding for all piping systems as shown on the Drawings and as listed below:

Service/Legend	Letter Color	Background Color	Tape Banding Color
Domestic Cold Water	White	Green	2" Green
Domestic Hot Water	Black	Yellow	2" Yellow
Domestic Hot Water Return	Black	Yellow	2" Yellow
Soft Cold Water	White	Green	2" Green
Soft Hot Water	Black	Yellow	2" Yellow
Industrial Cold Water	White	Green	2" Green
Fire Protection Water	White	Red	2" Red
Fire Auto Sprinkler	White	Red	2" Red
Fire Dry Standpipe	White	Red	2" Red
Fire Wet Standpipe	White	Red	2" Red
Fire Comb. Standpipe	White	Red	2" Red
Compressed Air	White	Blue	2" Blue
Roof Drain	White	Green	2" Green
Sanitary Sewer	White	Green	2" Green
Storm Sewer	White	Green	2" Green
Natural Gas	Black	Yellow	2" Black
Steam, PSIG	Black	Yellow	2" Black
Condensate Return, Gravity	Black	Yellow	2" Black
Condensate Return, Pumped	Black	Yellow	2" Black
Boiler Feed Water	Black	Yellow	2" Black
Chilled Water Supply	White	Green	2" Green
Chilled Water Return	White	Green	2" Green
Heating Water Supply	Black	Yellow	2" Yellow
Heating Water Return	Black	Yellow	2" Yellow
Condensing Water Supply	White	Green	2" Green
Condensing Water Return	White	Green	2" Green

7. Locations: Label pipes at the following points on each piping system:
   a. Adjacent to each valve in piping system.
   b. At every point of entry and exit where piping passes through a wall.
   c. On each pipe riser and junction.

d. At a maximum interval of 20 feet on pipe lines exposed and concealed above accessible ceilings.

e. Adjacent to all special fittings (regulating valves, etc.) in piping systems.

f. At every access door.

8. Underground Piping: Provide a continuous, preprinted, bright colored, plastic ribbon cable marker with each underground pipe regardless of whether encased. Locate directly over buried pipe, 6 inches to 8 inches below finished grade. Marker tape used in conjunction with buried plastic piping systems shall be special detector type.

F. Control System Devices: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the Contract Drawings.

2.05 GENERAL CONSTRUCTION COMPONENTS

A. Painting: Finish painting of mechanical systems and equipment will be under Spec Section 09 9100, “Painting," unless equipment is specified to be provided with factory-applied finish coats.

2.06 MISCELLANEOUS PROVISIONS

A. Flow Diagrams: Provide half-size prints of each system flow diagram, including air handling, steam, chilled water, heating water, domestic water, domestic HW, etc. Mount framed under plexiglass, and locate either on the associated AHU or on a nearby wall. Incorporate any as-built revisions.

PART 3 EXECUTION

3.01 INSTALLATION GENERAL REQUIREMENTS

A. Cooperation with Other Trades: Refer to other parts of these Specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. Be responsible for the size and location of all openings, foundations, etc.

B. Trenching and Backfilling: Provide all excavation, trenching and backfilling required for the installation of the work of this division.

C. Manufacturer's Instructions: Install all products in accordance with manufacturers' recommendations and the requirements of any applicable listings. If manufacturers' recommendations and/or requirements of applicable listings conflict with plans and specifications, report such conflicts to the Owner's Representative.

D. Field Measurements: Verify all dimensions and conditions governing the work. Examine adjoining work on which the work of this Division is dependent, and report any deficiencies.

E. Do not compromise the building structural, fire resistant construction or vapor barrier system.

F. Supports for Equipment and Systems: Foundations and structural supports for equipment will generally be provided by others. The contractor for this division shall provide supplementary supports as required to support equipment, distribution systems, and other components installed under this division. Prior to installing mechanical work, examine foundations and supports to ensure they are adequate to properly support the equipment. Provide all necessary foundations, structures, supports, inserts, sleeves, etc, for installation of mechanical and plumbing equipment, ductwork and piping, etc. Coordinate installation of such devices with all disciplines. Verify that the devices and supports are adequate as intended and do not overload the building structure.

G. Concealed or Buried Work: For work which is underground or which will be concealed by building construction, provide digital photographs to document the installation throughout the construction project, but not less than weekly. Include plans indicating where the photographs were taken. Notify the OR of when the work will be complete and provide OR a minimum five-day period to inspect the work after completion but prior to when it is backfilled or concealed by building construction.

H. Access Doors: Provide as required for access to valves, dampers, controls, or other items for which access is required for either operation or servicing. The type of access door shall be as required by the room finish schedule.

I. Alignment of Flexible Couplings: Flexible couplings between motors and driven equipment shall be aligned by a qualified service technician after the equipment is installed and ready for operation. Align equipment per manufacturer's recommendations under operating conditions and temperature. Provide written certification that each device has been so aligned.

J. Lubrication: Provide all oil for the operation of all equipment until acceptance. Be responsible for all damage to bearings while the equipment is being operated by Contractor up to the date of acceptance of the equipment. Protect all bearings and shafts during installation and thoroughly

grease shafts to prevent corrosion. Bearings for items of mechanical equipment shall be marked at each bearing location as to whether the bearing is a sealed type or relubricable type unit.

K. Tests: All tests shall be conducted in the presence of the designated and authorized Owner's Representative. Notify the Owner's one week in advance of all tests. Requirements for testing are specified under the sections covering the various systems. Provide all necessary equipment, materials, and labor to perform the required tests.

L. Protection of Material and Equipment:

1. Protect all work, materials and equipment furnished and installed under Division 23, whether incorporated in the building or not.
2. All items of mechanical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner as approved.
3. Protect all work and be responsible for all damage done to property, equipment and materials. Coordinate material storage with the Owner's Representative.
4. Pipe and duct openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. Plumbing fixtures shall not be used by the construction forces. At the completion of the work clean and polish fixtures, equipment and materials prior to turning them over to the Owner.

3.02 DRAWINGS

A. The drawings show the general arrangement of the piping, ductwork, equipment, etc. Follow them as closely as actual building construction and work of other trades will permit. Where discrepancies occur between Plans and Specifications, the more stringent shall govern. All Contract Documents shall be considered as part of the work. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required, and no attempt has been made to do so. Rather, the drawings convey the general design intent. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing fittings, valves, and accessories as required to meet such conditions. Show any such changes on the Record Drawings.

B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, submit an RFI.

C. Install equipment, piping, ductwork, and electrical systems with proper clearance for operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions, etc. Include proper clearance in front of and above electrical equipment as defined by the National Electric Code (NEC). Piping and ductwork systems shall not be routed through or above electrical equipment rooms, telecommunications rooms, elevator machine rooms, or electrical equipment spaces within mechanical equipment rooms.

D. Arrange all concealed mechanical systems carefully to fit within the available space without interference with adjacent structural and electrical systems. Make all necessary provisions for penetrations of piping and ductwork, including sleeves and blockouts in structural systems. The exact location of all exposed mechanical systems, including grilles, registers, and diffusers; access doors; sprinkler heads; piping and ductwork exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it relates to the aesthetic design for the facility.

3.03 PRESSURE RELIEF DEVICES

A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.

B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

3.04 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems for the benefit of the Owner prior to substantial completion will be allowed provided that a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.

B. Operation of equipment and systems for the benefit of the Contractor, except for the purposes of testing and balancing, will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.05 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

A. At completion of the project, submit searchable PDFs of these documents electronically. Organize bound information in a logical fashion with a table of contents and bookmarks for the different sections. Organize PDFs in a logical fashion to assist the operating personnel in retrieving desired data. Provide minimum two 1-hour sessions to instruct Owner's facility personnel in how to find information in the PDFs. Take attendance and submit the attendance list to the Owner's Representative. Include the following:

1. Approved Submittals.
2. Test reports.
3. O&M manuals and instructions covering all equipment supplied under this Division, with all non-applicable information crossed out. Clearly identify all required routine maintenance. Include parts lists.
4. A master Lubrication Chart listing each piece of equipment, the recommended oil or grease, and the recommended frequency of lubrication.
5. The names and addresses of at least one service agency capable of providing required maintenance for each item of equipment supplied.
6. Complete temperature control diagrams including control descriptions, system sequence of operation, operating instructions, control system maintenance and calibration information, wiring diagrams, and all control setpoints. See Section 23 0900 for additional requirements.

B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.

C. Submit O&M manuals for review and distribution to the Owner not less than two weeks prior to the date scheduled for O&M instructions as specified.

D. Demonstrate proper system operation to the owner's operating staff. Provide the services of the contractor and subcontractors (e.g., mechanical, T&B, temperature control, etc), as required to properly demonstrate system operation.

E. Provide the necessary skilled labor and helpers to operate the mechanical systems and equipment for a period of 2 days of eight hours each. During this period, instruct the owner’s facility staff fully in the operations, adjustment and maintenance of all equipment provided. Provide at least two weeks advanced notice, with a written schedule of each training session, the subject of the session, the Contractors' Representatives who plan to attend the session, and the

time for each session. Take attendance and submit attendance sheets to the Owner's Representative.

3.06 RECORD DRAWINGS

A. See Division 1, for additional requirements associated with Project Record Drawings.

B. Maintain a full-size set of marked-up prints showing the installed location and arrangement of all work under this division, and in particular where changes were made during construction. Keep record drawings accurate and up-to-date throughout the construction period. Owner’s Agents may request to review record drawings during construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFIs, bulletins, and change orders neatly taped or attached to record drawing set. At the completion of the project send the Engineer full-size plans clearly showing all changes from the original design marked up in red so as to facilitate the Engineer incorporating these changes into the Engineer’s CADD files. Forward record drawings to the Owner's Representative prior to submitting a request for substantial completion. Submittal of shop drawings will not be an acceptable alternative for record drawings.

3.07 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The Engineer may make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the work so as to determine if such work is proceeding in general accordance with the Contract Documents. This observation will not release the Contractor from his responsibility to supervise, direct, and control all construction work and activities. The Engineer has no authority over, or responsibility for means, methods, techniques, sequences, or procedures of construction or for safety precautions and programs, or for failure of the Contractor to comply with applicable laws, regulations, or codes.

B. Prior to substantial completion, request that the Engineer provide a final observation visit. Complete the attached "Final Observation Checklist," and include it with this request. For any items that are not applicable, mark them "N/A."

3.08 PROJECT CLOSEOUT

A. Submit written certification that all work complies with the specifications and applicable codes. Submit certifications and acceptance certificates including proof of delivery of record drawings, O&M manuals, spare parts required, and equipment warranties.

END OF SECTION

Project:_____ Date Submitted:_____

General Contractor:_____ Date of Final Mechanical System:_____

Mechanical Contractor:_____ Observation Requested:_____

CONTRACTOR'S MECHANICAL & PLUMBING CHECK LIST
(ALL APPLICABLE ITEMS MUST BE COMPLETED PRIOR TO FINAL OBSERVATION)

In advance of requesting a final mechanical observation for installed mechanical systems, please check all items that have been completed. For all items not applicable to this project mark N/A.

PLUMBING/PIPING

_____1. All plumbing fixtures are set, sealed and cleaned.

_____2. All domestic and HVAC pipe systems are insulated.

_____3. All pipe systems are identified with specified labels and directional arrows.

_____4. Floor sinks and drain grates are cleaned and debris removed.

_____5. Valve tags are installed.

_____6. Special equipment (water softeners, water heaters, piping systems, etc.,) have been checked and put into service.

_____7. Medical gas systems have been checked and certified.

_____8. Special piping systems have been cleaned and pressure tested.

_____ Fuel Handling
_____ Compressed Air
_____ Natural Gas
_____ Other

_____ Process Piping
_____ Nitrogen
_____ Vacuum
_____ Argon
_____ Medical Gas
_____ Other

_____9. Limestone chips have been installed in acid dilution sumps.

_____10. Plumbing/piping connections have been completed to Owner-furnished equipment and equipment furnished by other Contractors/Subcontractors.

_____11. Exterior wall hydrants have been cleaned.

_____12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.

_____13. Drains and relief lines from plumbing and HVAC equipment have been installed and secured in a proper manner.

_____14. All plumbing equipment and areas of equipment have been cleaned and debris removed.

_____15. All plumbing equipment required by the Specifications has been identified and/or numbered.

_____16. Domestic water systems sterilization has been completed.

_____17. Refrigerant piping/system has been charged and tested.

_____18. Strainers/suction diffusers have been cleaned.

_____19. Backflow preventers have been tested.

_____20. Air has been vented from all coils and systems.

_____21. Water treatment systems have been charged and tested.

_____ Chilled Water
_____ Hot Water
_____ Condenser Water
_____ Steam/Condensate

_____22. Ethylene glycol system has been charged with correct mixture and tested.

_____23. Water systems have been cleaned (X) and pressure tested (P)

_____ Chilled Water
_____ Hot Water
_____ Steam
_____ Condensate
_____ Fire Protection
_____ Sanitary Sewer and Vent
_____ Roof and Overflow Drains
_____ Condenser Water
_____ Non-potable Water
_____ Domestic Hot Water
_____ Domestic Cold Water
_____ Acid Waste and Vent
_____ Heat Recovery Piping
_____ Other (list)

_____24. PRVs have been adjusted (water, steam, gases).

FIRE PROTECTION

_____1. Fire protection piping is completed.

_____2. Fire protection system has been certified by the Fire Marshal's office.

_____3. All electrical interlocks between the fire sprinkler components and the fire panel have been checked for operation.

_____4. Spare sprinkler head, wrench and cabinet are installed.

HVAC - EQUIPMENT AND DUCTWORK

_____1. All ductwork has been sealed and insulated.

_____2. Return air paths and transfer openings have been verified.

_____3. Air handlers have been cleaned inside and out and construction filters removed and replaced with final filters.

_____4. All air handling equipment has been started and operated for the specified time.

_____5. All equipment isolators have been adjusted for specified deflection.

_____6. All VAV boxes, fan coils, or fan powered boxes are completed and operational.

_____7. All pump shafts and couplings have been aligned.

_____8. Ductwork, coils, housing, diffusers, registers and grilles have been cleaned.

_____9. Boilers have been fired and certified by the supplier.

_____10. Cooling towers have been started and inspected by the supplier.

_____11. Chillers have been charged, started and certified for operation by the supplier.

_____12. Fire dampers are accessible and fully operational.

_____13. All HVAC equipment has been lubricated.

_____14. HVAC equipment has been labeled in accordance with the Specifications.

_____15. Duct pressure testing is complete and accepted.

_____16. "HAZARDOUS AREA" signs installed where applicable.

_____17. Belt guards installed where applicable.

_____18. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.

_____19. Testing and balancing has been completed, and deficiencies noted have been corrected.

_____20. Special systems have been started and tested, such as: Humidification, laboratory hoods, kitchen hoods, and Owner-furnished items.

TEMPERATURE CONTROLS

_____1. Temperature control panels and devices have been labeled in accordance with the Specifications.

_____2. All control dampers close completely and edge and blade seals form tight seal.

_____3. All control valves have been piped as required by the Drawings.

_____4. Controls systems are completed and all control points are operating and recording properly.

_____5. All temperature control tubing and wiring is installed and secured in accordance with the Specifications and the electrical code.

_____6. Smoke removal fans and/or smoke detectors have been tested for operation and shutdown.

_____7. Freezestats have been tested ensuring fan shutdown and full damper closure.

_____8. Operator training for temperature controls has taken place.

_____9. Refrigerant sensors and equipment room shutdown have been tested.

GENERAL ITEMS

The following specified items have been submitted:

_____1. Record Drawings (to be submitted prior to final payment to the Contractor).

_____2. Operation and maintenance manuals.

_____3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 23 0500).

_____4. Testing and balancing reports.

_____5. Test kits furnished to Owner.

_____ Flow Measuring Devices
_____ Flow Balance Valves
_____ Flow Control Devices

_____6. Temperature control schematics and sequence of operation.

_____7. Wall-mounted lubrication, valve, and temperature control charts have been installed.

DIVISION 23 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS
PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____Paragraph/Line: _____Specified Item: _____

Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions?
   YES ☐ NO ☐
   If YES, explain:_____
2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐
3. List differences between proposed substitutions and specified item.
   Specified Item Proposed Substitution
   _____ _____
   _____ _____
4. Does substitution affect Drawing dimensions? YES ☐ NO ☐
5. What affect does substitution have on other trades?_____
6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
   If YES, explain:_____
7. Will substitution affect progress schedule? YES ☐ NO ☐
   If YES, explain:_____
8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
   If YES, explain:_____
9. Does proposed product contain asbestos in any form? YES ☐ NO ☐

SUBMITTED BY: Firm: _____ Date: _____
Address: _____
Signature: _____ Telephone: _____

For Engineer's Use Only

Accepted_____	Not Accepted _____	Received Too Late _____
By: _____		Date:_____
Remarks:_____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT:_____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2:_____

Date: _____

SECTION 23 0504 - PIPE AND PIPE FITTINGS

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures furnished under Division 23 shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

1.03 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 PRODUCTS

2.01 PIPE AND PIPE FITTINGS

A. Piping system materials shall be furnished as specified under the Sections describing the various piping systems. Pipe fittings shall be compatible with the piping systems in which they are installed.

B. Pipe fittings for steel piping systems shall be weld, screwed or mechanical couplings. Butt weld fittings shall be manufactured by Weld-Bend, Laddish, or equivalent, standard or extra strong as specified in the applicable Sections of this Specification, conforming to ANSI Standard B16.9. All

90^0 weld elbows shall be long radius unless otherwise specified. Wherever tee connections are required in the piping system, manufacturer's straight or reducing tees shall be utilized. The use of fittings formed from welded pipe or pipe sections will not be permitted. Forged steel "Weld-O-Lets", "Branch-O-Lets", and "Thred-O-Lets", as manufactured by Bonney Forge or equivalent, may be utilized for welded branch and tap connections up to one-half the size of the main. Forged steel half-couplings conforming to ANSI B16.11 may be used for drain, vent and gauge connections. Flanges shall be forged steel weld neck or slip-on, raised face, Class 150 or 300 as specified in the applicable Sections of this Specification with full face or ring type non-asbestos gasket material suitable for the application.

C. Socket weld fittings shall be Schedule 40, 2000 pound or Schedule 80, 3000 pound construction, as specified in the applicable Sections of this Specification, conforming to ANSI B16.11, as manufactured by Grinnell or equivalent.

D. Screwed fittings shall be Class 150 standard or Class 300 extra heavy, black or galvanized, malleable iron or cast iron, as specified in the applicable Sections of this Specification, as manufactured by Grinnell or equivalent. Screwed malleable iron fittings shall conform to ANSI B16.3 and cast iron screwed fittings shall conform to ANSI B16.4. Bushing reduction of a single pipe size or use of close nipples will be permitted.

E. Pipe couplings and fittings as manufactured by Victaulic, Tyco-Grinnell, or equivalent may be utilized for steel piping systems in lieu of butt weld fittings, as specified in the applicable Sections of this Specification. Couplings shall consist of ductile or malleable iron housing, with gasket, and nuts and bolts required to secure the unit. Gaskets shall be molded of synthetic rubber or other compound as recommended by the manufacturer for the fluid application including required pressure and temperature operating ranges. Fittings utilized in conjunction with Victaulic type piping system shall be manufacturer's full flow cast iron, malleable iron, or steel fittings with grooves designed to accept mechanical couplings. All piping shall be prepared in accordance with manufacturer's specifications, furnished for factory or field installed roll grooves without metal removal. Square cut grooves will not be permitted. Assembly of couplings, fittings and piping shall be in accordance with manufacturer's published instructions. Gaskets, pipe ends, fittings and coupling housings shall be properly lubricated with water-based type lubricant furnished by the coupling manufacturer. Couplings shall be Victaulic Style 07 "Zero-Flex" or equivalent, rigid coupling through 24" size. For applications in conjunction with connections to items of equipment such as boilers, water

chillers, cooling towers, etc., Victaulic Style 75 or equivalent couplings shall be utilized. Adapter connections between Class 125 and 150 flanged components and grooved piping system shall be made utilizing Victaulic Style 741 and 742 or equivalent flange adapter. Branch and tap connections up to one-half the size of the main may be made utilizing Victaulic Style 72 or equivalent outlet couplings and Style 920 or 921 or equivalent branch outlet connections.

F. Pipe fittings for copper piping system shall be wrought copper conforming to ANSI B16.22. Cast brass fittings conforming to ANSI B16.23, may be utilized for sanitary drainage, waste and vent systems, HVAC gravity condensate drainage system, and other non-pressure applications.

G. Bronze flanges, Class 125 and Class 150, shall conform to ANSI B16.24. "T-drill" or equivalent mechanically formed tee connections and couplings may be utilized for water and drainage services. Installation of mechanically formed connections shall be in strict accordance with the manufacturer's specifications. Mechanically extracted collars shall be formed in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Branch tube shall be notched and dimpled in a single process to provide free flow such that the branch tube penetrates the fitting sufficiently for proper brazing and ensures that the branch tube does not obstruct the flow in the main line. All joints shall be brazed with cadmium brazing alloy. Mechanically formed collars shall be listed by the National Standard Plumbing Code, I.A.P.M.O., and Underwriters' Laboratory.

H. Cast iron fittings for cast iron sanitary soil, waste, and venting piping systems shall be as specified in Division 22.

I. Ductile iron fittings for ductile iron water service piping systems shall be as specified in Division 22.

2.02 FLOOR, WALL AND CEILING PLATES

A. Where uncovered, exposed pipes pass through finished floors, finished walls, or finished ceilings, they shall be fitted with chromium plated spun brass escutcheon plates. Plates shall be large enough to completely close the hole around the pipe, and shall be not less than 1-1/2" or more than 2-1/2" larger than the diameter of the pipes. All plates shall be securely held in place.

2.03 UNIONS

A. Piping 2-1/2" and larger shall be provided with bolted flange union connections. Weld flanges and bolting shall conform to ANSI B16.5. Bronze flanges shall conform to ANSI B16.24. Flange class

shall be as specified in the applicable Sections of the Specifications.

B. Malleable iron grooved joint unions with brass to iron seats, Class 125, 250, or 300, as required by the application and compatibility requirements with the piping system fitting classification, conforming to MSS SP-77 and ANSI B16.39, shall be provided in piping systems 2" and smaller. Copper unions conforming to ANSI B16.22 shall be provided in copper piping systems. Union connections shall be installed at all coils, control valves, equipment connections, and at other locations shown on the drawings, and required for proper system operation and maintenance.

2.04 DIELECTRIC FITTINGS

A. Dielectric insulating fittings shall be provided to connect dissimilar metals, such as copper tubing to ferrous metal pipe. Connections 2" and smaller shall be threaded dielectric union conforming to ANSI B16.39. Connections 2-1/2" and larger shall be flange union with dielectric gasket and bolt sleeves, conforming to ANSI B16.42. Insulating fittings will not be required between bronze valves and copper piping, unless otherwise specified.

2.05 PIPE HANGERS AND SUPPORTS

A. All piping shall be rigidly supported from the building structure by means of hanger assemblies properly selected and sized for the application in accordance with the manufacturer's recommendations and specifications. Pipe hangers shall be Grinnell, B-Line, Erico, or equivalent.

B. No attempt has been made to show all required piping supports in all locations, either on the drawings or in the details. The absence of pipe supports and details on any drawing shall not relieve the Contractor of the responsibility for furnishing and installing proper hangers and supports throughout.

C. Piping hangers shall be spaced on the scheduled maximum spacing and shall have hangers not more than one foot from each elbow and other changes in direction or elevation. Provide additional hangers and supports at valves, strainers, in-line pumps adjacent to flexible connections, and other required heavy components. Piping system shall be installed in an approved manner and shall not overload the building structural frame. Contractor shall provide additional hangers and miscellaneous steel supports as may be required to distribute the piping system load over multiple structural members where required or directed. Maximum allowable spacing for steel and copper piping, other than fire protection piping, shall be as scheduled in Table No. 1.

TABLE NO. 1

MAXIMUM SUPPORT SPACING FOR STEEL AND COPPER PIPING SYSTEMS

Steel Piping	Maximum Spacing
1/2"	5'-0"
3/4" and 1"	6'-0"
1-1/4" through 2"	8'-0"
2-1/2" through 6"	10'-0"
8" through 12"	12'-0"

Copper Piping	Maximum Spacing
1/2"	5'-0"
3/4" and 1"	6'-0"
2-1/2" through 4"	8'-0"
5" and larger	10'-0"

D. Round rods supporting the pipe hangers shall be of the minimum dimensions as scheduled in Table No. 2. Hanger rods shall be hot-rolled steel, ASTM A-36 or A575, galvanized, all-thread. Provide for controlling level and slope by turnbuckles or other approved means of adjustment and incorporate locknuts.

TABLE NO. 2

HANGER ROD SIZE FOR PIPE HANGER SUPPORTS

1/2" to 2" pipe	3/8" rod
2-1/2" to 3" pipe	1/2" rod
4" to 5" pipe	5/8" rod
6" pipe	3/4" rod
8" to 12" pipe	7/8" rod
14" and 16" pipe	1" rod
18" and 20" pipe	1-1/4" rod
24" and 30" pipe	1-1/2" rod

E. Cast iron soil, waste and vent piping shall be provided with steel clevis type hangers. Grinnell Fig. 590 at each pipe joint and at each fitting.

F. Fire protection system shall be supported in strict accordance with the requirements contained in the applicable NFPA pamphlets and as specified in Division 21, Fire Suppression Systems.

G. Hangers, clamps and other support materials in contact with copper piping shall be copper or copper plated to prevent electrolysis. Hangers for copper piping shall be copper plated adjustable ring type Grinnell Fig. CT-269, adjustable swivel ring, Grinnell Fig. CT69, Fig. CT-65 or adjustable clevis type or equivalent. Provide minimum 10 mil plastic wrap around copper pipe at any ferrous point of attachment including trapeze hangers, clamps, and other supports.

H. Hangers for steel shall be steel clevis type hangers, Grinnell Fig. 260 or equivalent.

I. Where piping is installed side by side, the Contractor may support the piping utilizing trapeze type hanger assemblies. Horizontal trapeze member shall be galvanized steel channel, not less than 1-1/2" x 1-1/2" x 12" gauge, or Unistrut. Contractor shall provide heavier steel members as required for the load to be supported and the distance span. Trapeze hangers shall not be utilized for fire and sprinkler piping and plumbing drain waste and vent piping. Hanger rods shall be as specified above, properly sized for the load supported but not less than 5/8" diameter. Un-insulated copper piping shall be isolated from the steel trapeze. Individual pipe shall be guided on the horizontal member at every other hanger point with 1/4" U-bolt fabricated from steel rod. Provide full circle galvanized sheetmetal insulation shield for insulated piping at trapeze hangers with U-bolt guide and galvanized sheetmetal insulation half-shield at other trapeze hangers. Insulation shield shall be 18 gauge minimum, Grinnell Fig. 167 or equivalent.

J. Special piping supports including tunnel support racks, wall support racks, floor mounting pedestal type supports shall be provided as indicated on the drawings, and as required for the proper support for the piping systems.

K. Supports for special piping systems including refrigeration piping shall be provided as recommended by the pipe manufacturer and as specified in the applicable Sections of this Specification.

L. Vertical piping shall be supported at each floor level by means of riser clamps, Grinnell Fig. 261 and Fig. G-121, Erico, copper clad for copper piping systems, or equivalent. Proper allowance for the expansion and contraction of the vertical risers shall be provided. Contractor shall submit shop drawings indicating proposed method for support and control of expansion and contraction of vertical piping.

M. The use of pipe hooks, chains, or perforated iron for pipe hanger supports will not be permitted.

N. All insulated piping systems specified in Section 22 0700, Plumbing Insulation and Section 23 0700, HVAC Insulation, shall be provided with individual hangers sized to encircle the insulation. See applicable sections for insulation thickness requirements. The specified piping systems where supported by means of trapeze hangers shall not rest directly on the trapeze horizontal members. The insulation at hangers and trapeze hangers shall be protected by means of insulation shield, Grinnell Fig. 167, Erico, or equivalent. Grinnell Fig. 160, Erico, or equivalent, curved steel pipe saddle, shall be provided at roll hangers. Contractor shall provide section of high density calcium silicate insulation or thermal hanger shields as manufactured by Pipe Shields, Inc., or equivalent, at

all insulation piping system hanger and support points for piping 1-1/2” or larger.

O. Attachment of piping hangers to the building structure shall be provided in a manner approved by the Architect. The Contractor shall provide concrete inserts in the building construction at the time the concrete is poured and hangers shall be attached to these inserts. Self-drilling expansion anchors, Federal Specification FF-S-325, may be used in concrete construction not less than 4" thick. Applied load shall not exceed manufacturer's approved ratings. Power driven fasteners may be used in existing concrete or masonry not less than 4" thick where approved by the Architect. Attachment to steel construction shall be approved by the Architect.

2.06 PIPE SLEEVES

A. ipe sleeves in concrete and masonry construction, footings and beams shall be Schedule 40 black steel pipe through 10”, standard wall thickness for sizes 12” and larger, ASTM A 53, A 106, or A 120.

1. For sleeve installation below grade in cast in place concrete wall or floor and masonry construction, sleeves shall be GPT type WS sleeves with minimum 2” water-stop collar or equivalent. The sleeves shall be provided free of welding slag. The water stop collar shall be welded all around on both sides to the sleeve at the point on the sleeve that positions it at the midpoint of the wall. Sleeve shall be primed inside and outside with Sherwin Williams Water Base Red Primer, or approved equivalent.

B. Pipe sleeves in gypsum board construction shall be galvanized steel metal, minimum 24 gauge; round tube closed with welded longitudinal joint and flanges on both sides.

C. Pipe sleeves shall be furnished and set by the Contractor and they shall be responsible for their proper and permanent location. Piping will not be permitted to pass through footings, beams or ribs except with written consent of the Architect.

D. Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through gypsum board stud walls, concrete, and masonry construction and at all fire and smoke rated walls and partitions.

E. Where insulated piping is installed, calcium silicate inserts to match the insulation thickness and extending 1" past the sleeve on both ends, shall be provided.

F. Sleeves shall be not less than 1" or more than 2" larger in diameter than the pipe to be installed.

G. Pipe sleeves in floors shall extend 2" above finished floor in chases and equipment room areas unless

otherwise approved by the Architect. Openings between piping and sleeves shall be made watertight with plastic cement installed to a minimum depth of 2".

H. Un-insulated piping passing through fire walls, smoke wall, sound control walls and air plenum separations shall be sealed airtight to the adjacent construction by means of UL approved fire stop sealant materials.

I. Insulated piping passing through fire walls and smoke walls shall be provided with Calcium Silicate pre-formed pipe insulation of thickness to match adjacent piping, extending minimum 1-inch beyond sleeve in each direction.

1. For penetrations through concrete or masonry walls/floors, the space between the piping sleeve and insulation shall be sealed airtight with UL approved firestop sealant and packed with minimum 4" thickness mineral wool (minimum 4 pcf density) tightly packed and recessed to accommodate sealant.
2. For penetrations through gypsum board wall construction, both sides of the annular space between the insulation and sleeve shall be sealed with UL approved firestop sealant.

J. Penetrations of gypsum board sound walls and air plenum separators shall be caulked airtight with an approved UL firestop sealant.

2.07 PIPE SLEEVE SEAL SYSTEMS

A. Provide pipe sleeve seal systems by one of the following:

1. Link-Seal Modular Wall Penetration Seal as manufactured by GPT.
2. Metraflex Company
3. Proco Products, Inc.

B. Description: Modular sealing element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Plastic, reinforced nylon polymer
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

C. Pipe sleeve seal system shall be utilized at all exterior wall penetrations.

D. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Provide and erect, according to the best practices of the trade, all piping shown on drawings and required for the complete installation of these systems. The piping shown on the drawings shall be considered as diagrammatic for clearness in indicating the general run and connections, and may or may not in all parts be shown in its true position. The piping may have to be offset, lowered or raised as required or as directed at the site. This does not relieve the Contractor from responsibility for the proper erection of systems or piping in every respect suitable for the work intended as described in the specifications. In the erection of all piping, it shall be properly supported and proper provisions shall be made for expansion, contraction and anchoring of piping. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate installation will not be permitted. All pipes shall have burrs and/or cutting slag removed by reaming or other cleaning methods. All changes in direction shall be made with fittings. All open ends of pipes and equipment shall be properly capped or plugged to keep dirt and other foreign materials out of the system. Plugs of rags, wool, cotton waste or similar materials may not be used in plugging. All piping shall be arranged so as not to interfere with removal and maintenance of equipment or filters or devices; and so as not to block access to manholes, access openings, etc. Flanges or unions as applicable for the type of piping specified shall be provided in the piping at connections to all items of equipment including refrigeration machines. All piping shall be so installed to ensure noiseless circulation. All valves and specialties shall be so placed to permit easy operation and access, and all valves shall be regulated, packed and adjusted at the completion of the work before final acceptance. All piping shall be erected to ensure proper draining. Water piping shall be pitched a minimum of 1" per 50 feet for draining.

3.02 JOINTS

A. Caulked Joints: Caulked joints in hub-and-spigot piping and vent piping shall be packed firmly with white oakum, "Sealite No. 110," or hemp and caulked with pure molten lead not less than 1" deep. Resilient molded gasket joints or "Ty-Seal" may be used in lieu of lead and oakum for sanitary soil, waste and vent piping. No-hub pipe and fittings will be accepted with the exception that no-hub pipe and fittings shall not be allowed for buried installation.

B. Screwed Joints: Shall have American Taper pipe threads. Ream pipe ends and remove burrs after threading. Make up joints using Teflon tape or other approved compound applied to the male threads only.

C. Solder Joints: Copper tubing shall be cut square and burrs removed. Both inside of fittings and outside of tubing shall be well cleaned before sweating. Care shall be taken to prevent annealing of fittings and hard drawn tubing when making connections. Joints for sweated fittings shall be made with a non-corrosive paste flux and solid 95-5 tin-antimony wire solder, unless otherwise specified. Cored solder will not be permitted. 50/50 lead solder shall not be permitted for any applications.

D. Welded Joints: On black steel piping 2-1/2" and above in size, the joints may be welded. Welding shall be done using either gas or electric welding equipment. Certified welders shall be used. Welders shall be certified in accordance with Section IX of ASME Boiler and Pressure Vessel Code, latest edition. All pipe surfaces shall be thoroughly cleaned before welding. Each joint shall be beveled before being welded. Piping shall be securely aligned and spaced, and the width of circumferential welds shall form a gradual increase in thickness from the outside surface to the center of the weld. All fittings used in the welded piping systems shall be standard ASA fittings, and shall be of standard pipe thickness. The Contractor shall provide a fireproof mat or blanket to protect the structure and adequate fire protection at all locations where welding is done. The use of fittings formed from welded pipe sections will not be permitted.

E. Flanged Joints: Flanged joints shall conform to the American Standard for cast iron flanged pipe fittings, Class 125, 150 or 300 as specified in the applicable Sections of these specifications. Gaskets shall be full face or ring type, non-asbestos, suitable for the service on which used.

3.03 PUMP AND EQUIPMENT CONNECTIONS

A. All piping connecting to pumps and other equipment whether connected utilizing flexible connectors or with solid pipe connectors, shall be installed without strain at the pipe connection of the

equipment. The Contractor shall be required, if so directed, to disconnect piping to demonstrate that piping has been so connected.

3.04 EXPANSION AND CONTRACTION

A. The Contractor shall make all necessary provisions for expansion and contraction of piping with offsets or loops and anchors as required to prevent undue strain. Contractor shall provide shop drawings for proposed method and arrangement for control of expansion and contraction of piping. See Section 23 0505 for expansion joints, expansion compensators, pipe guides and pipe anchors.

3.05 PROTECTIVE COATINGS

A. All underground steel pipe shall be wrapped with "Scotchwrap" No. 50 tape or equivalent, to give not less than two complete layers on the entire underground piping system, or piping shall have X-Tru-Coat factory applied plastic protective covering.

3.06 FLUSHING, DRAINING AND CLEANING PIPE SYSTEMS

A. The Contractor shall flush out all water systems with water before placing them in operation. Other systems shall be cleaned by blowing them out with compressed air or nitrogen. After systems are in operation and during the test period, all strainer screens shall be removed and thoroughly cleaned.

3.07 TESTING

A. Before any insulation is installed or before piping is covered or enclosed, all piping systems shall be tested and proven tight at not less than 150% of the maximum service pressure which the piping systems will be required to handle. Piping system tests shall be as specified in the applicable sections of this Specification. All tests shall be witnessed and approved by the Architect.

B. All labor, material, and equipment required for testing shall be furnished by the Contractor. The Contractor shall be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure shall be removed from the line or blanked off before applying the tests. To perform tests, all lines shall be flushed and cleaned.

C. All safety measures required by codes or ordinances or reasonably applicable to the situation shall be provided by the Contractor in conjunction with the testing of the piping systems.

D. Equipment or piping to be pressure tested shall not be insulated, covered, or concealed prior to that test. Underground piping may be partially backfilled prior to pressure test when required for

application of the test except that joints shall remain exposed until after the test. Tie rods, clamps etc., shall be in place and fastened.

E. Tests shall not be used to establish pressure ratings.

F. Protect all piping and equipment against over pressure, collapse from vacuum, and hydraulic shock during the filling, testing and draining procedures. Seats of iron valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Pressure tests against other closed valves shall not exceed twice the normal rating.

G. Apply test pressure only after the system and test medium are at approximately the same temperature, preferably not less than 60^0F. Note that some applicable codes may require testing above a specified minimum temperature.

H. Remove from the system all pumps, turbines, traps, expansion joints, instruments, control valves, safety valves, rupture discs, orifice plates, etc., which might be damaged by the test. Also remove all items such as orifice plates which might trap air in a system to be hydrostatically tested. Disconnect all instruments and air lines where copper tubing starts.

I. Systems may be separated into sub-systems for testing if such action will expedite or simplify the testing.

J. During hydrostatic testing of lines, provide temporary supports to prevent overstressing supports or hangers. When tests are completed, remove all temporary supports, locks, stops, etc., and adjust supports for their cold load and alignment.

END OF SECTION

SECTION 23 0505 – PIPING SPECIALTIES

PART 1 GENERAL

1.01 REQUIREMENTS

A. Furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform to applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 0523, Valves.

1.03 SUBMITTAL DATA

A. Furnish complete submittal data for all piping specialties including manufacturer’s specifications, performance characteristics, ratings, installation instructions, certifications and approval of listing agencies, wiring diagrams, and selection analysis.

PART 2 PRODUCTS

2.01 STRAINERS

A. Strainers suitable for the application shall be furnished and installed on the high pressure side of pressure reducing valves, pressure regulating valves, suction side of pumps, inlet of indicating and control instruments and equipment subject to sediment damage, and as shown on the drawings. Strainers shall be "Y"-type unless basket strainers are indicated. Tee-type strainers will

not be accepted. Strainer element shall be removable without disconnecting piping. Screens shall be Type 304 stainless steel with 1/8 inch perforations for water service, and 1/16 inch perforations for steam, air and gas services. Every strainer shall be provided with a blow-off connection not less than 1/2" NPT and provided with a ball valve the full size of the strainer outlet tapping. Strainers located outside of mechanical equipment rooms and above ceilings shall be provided with hose connection and cap on the outlet of the blowoff valve. Strainers shall be Spirax Sarco, Armstrong, Febco, Grinnell, Hoffman, Keckley, Metraflex, Mueller, Yarway, or equivalent.

B. Strainers 2" and under for copper piping systems shall be threaded connection, bronze body, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco BT or equivalent.

C. Strainers 2" and under for steel piping systems shall be threaded connection, bronze body, as specified above or cast iron body as specified herein, except all strainers in galvanized steel domestic water systems shall be bronze body. Cast iron strainers shall be threaded connection, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco IT or equivalent.

D. Strainers 2-1/2 inches or larger shall be standard flanged connection ANSI-125, cast iron body, suitable for steam, oil , gas, and liquid service, 125 maximum working pressure at 353^{o} F maximum temperature, Sarco CI-125.

E. Basket strainers 2" and larger shall be standard flanged ANSI-125, cast iron body bolted cover, Type 304 stainless steel screen, suitable for steam or liquid service, 125 maximum working pressure at 353^{o}F maximum temperature, Sarco 528-B-125, or equivalent.

2.02 THERMOMETER AND THERMOMETER WELLS

A. Either liquid filled or digital type, vari-angle, 3-1/2" stem for pipe sizes through 6" and 6" stem for pipe sizes 8" and larger, dual scale (degrees F & C), separable brass socket, extension neck where installed in insulated piping, and accuracy 1% of range. Winters, Weiss, Moeller, Trerice, Weksler, Duro, or equivalent.

1. Liquid Filled Type: 9" case, straight form, V-shaped, high pressure die cast aluminum, baked enamel finish, with heavy glass-protected front firmly secured with spring action, and organic liquid filled magnifying lens. Winters 9IT or approved equal.

2. Digital Type: May be used both indoors or in outdoor locations not exposed to sunlight, high impact ABS plastic housing, suitable for operation at 16 Lux. Winters 9IT or approved equal.

B. Ranges: Provide the following ranges except where otherwise indicated:

Heating Water	30-240 degrees F
Chilled Water, Condenser Water, Domestic Cold Water	0-120 degrees F
Domestic Hot Water	30-180 degrees F

2.03 TEMPERATURE AND PRESSURE TEST PLUGS

A. 0.25 or 0.5-inch NPT with brass body, EPDM core, and brass gasketed cap. Winters, Peterson, or approved equal. Supply one pressure/temperature test kit with two 4" Duro #105 pressure gauges of 1% accuracy and ranges as required by application; and two 2" Tel-Tru #39R Bi-metal thermometers with 8" stem, 1% accuracy, and ranges as required by the applications; and a protective carrying case.

2.04 FLEXIBLE CONNECTORS

A. Furnish and install flexible connectors at locations indicated on the drawings and at all piping connections associated with equipment mounted on or hung from vibration isolators. Flexible connectors shall be constructed of multiple ply nylon cord fabric and neoprene, operating pressure 150 PSIG at 220^{O}F through 12" size and operating pressure of 125 PSIG at 220^{O}F for sizes 14" through 24". Provide butyl or Hypolon liner and applications with fluid temperatures in excess of 225^{O}F.

B. Flexible connectors shall be single or twin sphere with Class 150 flange connections for sizes 2-1/2" and larger and threaded connections with galvanized female unions for sizes 3/4" through 2". Mason Industries MFTCR, Hyspan, Metra-Flex, Keflex, Proco, or equivalent. Flexible connectors required for outdoor installation shall be braided stainless steel type.

C. Installation of flexible connectors shall be in strict accordance with manufacturer's recommendations. Spacing between piping system flanges shall be based on the flexible connector's expanded length corresponding to the system's operating pressure. Control rods or cables shall be provided for units installed in unanchored applications where system operating pressure and dynamic forces exceeds manufacturer's recommendations for unrestrained installations.

PART 3 EXECUTION

3.01 INSTALLATION

A. All specialties shall be installed in accordance with the best standard practices and as recommended by the manufacturer.

B. Install thermometers so they are easily readable from operator level.

C. Where thermometers, gauges, vents and test fittings occur in insulated piping systems or on insulated equipment, extension necks shall be provided to extend beyond the insulation.

3.02 STRAINERS

A. All strainer screens, including basket strainers and suction diffusers, shall be removed and cleaned prior to commencing testing and balancing work and shall be maintained clean through project final acceptance by the Owner. Suction diffuser start-up strainers shall be removed prior to final system testing and balancing work.

3.03 TEST AND ADJUSTMENT

A. Field adjust all water pressure regulating valves, flow switches, water level controls, and specialties to provide required system operation.

B. Field test and verify the operation of all safety devices including water relief valves and temperature and pressure relief valves.

3.04 RELIEF VALVE DISCHARGE

A. Water pressure relief valve and water temperature and pressure relief valve discharges shall be piped full size to the outside of the building or discharged indirectly in a properly sized building floor drain or floor sink, and as allowed by the Building Mechanical and Plumbing Codes. When the operating discharge temperature is in excess of 212^{o}F, the discharge shall be equipped with a splash shield or centrifugal separator.

B. Water reduced pressure backflow preventer discharge shall be piped full size to the outside of the building or discharged indirectly into a properly sized building floor drain or floor sink as allowed by the Building Mechanical and Plumbing Codes. Provide a bronze air gap funnel with stainless steel fasteners for installation under reduced pressure backflow prevention relief valve. Febco Model AGD or equivalent, 1" discharge pipe size for backflow preventer size through 2".

END OF SECTION

SECTION 23 0523 - VALVES

PART 1 GENERAL

1.01 REQUIREMENTS

A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.

C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.

2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.02 RELATED SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0523 for Valve Identification.

C. Section 23 0504 for Pipe and Pipe Fittings.

D. Section 23 2313 for Refrigerant Piping System.

E. Division 21 for fire suppression system valves and tamper switches.

F. Division 22 for plumbing system.

1.03 SCOPE

A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.04 VALVE REQUIREMENTS

A. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Tyco-Grinnell, or equivalent.

B. All lubricated plug valves shall be as manufactured by Rockwell, Walworth, Homestead, or equivalent.

C. Butterfly valves shall be as manufactured by Milwaukee, W. C. Norris, Centerline, Crane, Demco, Keystone, Tyco-Grinnell, Victaulic, Nibco, or Dezurik, or equivalent. Butterfly valves may be used for closed circuit chilled water, heating hot water (200^{o}F maximum) run-around coil and heat pump circulating water systems and for condensing water systems. Butterfly valves shall not be used for domestic water or other non-specified service.

D. Ball valves shall be utilized in lieu of gate valves and globe valves for all HVAC and plumbing systems for sizes 2" and smaller.

E. Butterfly valves may be substituted for gate, globe and ball valves for specified services, and for other services as may be approved by the Architect.

F. All valves furnished under Division 22 and 23, of the same type, shall be products of a single manufacturer unless otherwise approved by Owner's Representative.

G. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

PART 2 PRODUCTS

2.01 GENERAL SERVICE VALVES, HVAC AND PLUMBING SYSTEMS

A. Gate Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, solid disc, rising stem, gland packed, non-asbestos packing. Milwaukee 148 (Threaded) or equivalent; Milwaukee 149 (Solder), or equivalent.

B. Gate Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 125 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2885 or equivalent.

C. Globe Valves - 2" and Smaller, Class 125: Valves 2-1/2" and smaller shall be of ASTM B-62, Class 125 construction, bronze trim, gland packed, non-asbestos packing. Milwaukee 502 (Threaded), or equivalent; Milwaukee 1502 (Solder) or equivalent.

D. Globe Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and Larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 125 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2981M or equivalent.

E. Check Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, Y-pattern, swing type design, teflon seat, disc for steam service, Buna-N for water service. Milwaukee 509 (Threaded) or equivalent; Milwaukee 1509 (Solder) or equivalent.

F. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 125 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2974M or equivalent.

2.02 BUTTERFLY VALVES

A. Valves 2-1/2" and larger shall be full lug pattern, ASTM A-126, Class B cast iron body, 416-SS stems, aluminum/bronze disc, EPDM liner and seats (-30°F to 275°F) w/rigid phenolic cartridge, 200 PSIG working pressure with Bubble tight shut-off. Valves shall be for mounting between flanges with lugs drilled and tapped so that pipe may be disconnected on either side of valve with opposite end remaining under pressure. Milwaukee ML-123-E or equivalent.

B. Valves 4" and smaller shall be provided with level handler operator with spring loaded lock stops. Valves 5" and larger shall be furnished with manual gear operator with hand wheel.

C. Valves installed for insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing.

D. Butterfly valves furnished for use in grooved piping system shall meet the material specification requirements as specified herein.

2.03 BALL VALVES

A. Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, 600 PSI W.O.G. Two-piece body, chrome plated ball, blowout proof stem, reinforced TFE seats, non-asbestos packing. Milwaukee BA-100 (threaded) or equivalent. Milwaukee BA-150 (solder) or equivalent.

B. Valves installed on insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing. Cutting or notching of the insulation or bending of handles shall not be permitted.

2.04 NATURAL GAS VALVES

A. Valves 3/4" and Smaller: Bronze natural gas cock, Walworth No. 590 (square head), Walworth 591 (flat head) or equivalent.

B. Valves 3" and Smaller: Ball valve shall be cast of ASTM B-584 bronze, Class 250 construction, threaded connections, chrome plated big ball and stem, RDTFE seat and stem packing, blow-out proof stem, UL Listed for natural gas service, Apollo 80-100 Series or equivalent.

C. Valves 4" and Larger: Lubricated plug valve, cast iron construction, 175 PSIG W.O.G., threaded connection for valves 2" and smaller, Class 125 Flange connections, level handle operator. Walworth No. 1797F (Flanged) or equivalent.

PART 3 EXECUTION

3.01 INSTALLATION

A. All valves shall be installed in locations which will allow easy operation and facilitate maintenance.

B. Gate and Globe valves shall be installed with stems horizontal.

END OF SECTION

SECTION 23 0593 - TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

PART 1 GENERAL

1.01 GENERAL

A. Conform with applicable provisions of the General Provisions and the General Requirements.

B. Testing, adjusting and balancing (TAB) shall be performed by a TAB Agency which is independent of the Mechanical Contractor.

C. The TAB Agency's efforts shall be paid for by the [Contractor and included in the mechanical contract price.] [Owner and shall not be included in the mechanical contract price.]

D. Unless specifically noted, all work specified in this section shall be included in the scope of the TAB Agency's work. But some work described in this section is to be performed by the mechanical contractor, controls contractor, or others, and that work is specifically noted to be by these entities.

1.02 SCOPE

A. Provide TAB for the systems and equipment installed under Division 23, including but not limited to:

1. Supply and exhaust air systems including process and kitchen systems.
2. Return air where specifically noted.
3. Hydronic systems including domestic HW return systems.

B. Provide all labor, instruments, and tools necessary to test, adjust and balance the systems shown on the drawings and/or described in these specifications. Check equipment performance, take measurements, adjust systems and equipment to provide specified performance, and report results. Submit reports to keep all parties posted on the progress of the TAB work.

C. Where the TAB effort indicates deficiencies in system performance, TAB Contractor shall take the lead in a collaborative effort to trouble-shoot and resolve these deficiencies. Engage the assistance of others where necessary, starting with the Mechanical Contractor and Controls Subcontractor. Take additional measurements as required to identify the cause of the deficiencies, perform additional TAB as required to bring the system in compliance with the design intent. Engage the assistance of the Engineer and others where necessary. Indicate final

setpoints and readings in a final TAB report.

D. Include three days of effort on site for tests and/or balancing as directed in writing by the Owner's Representative beyond that described herein, but prior to substantial completion.

E. Include two days on site for TAB efforts as directed in writing by the Owner's Representative after substantial completion.

1.03 STANDARDS AND DEFINITIONS

A. Perform all work in accordance with these specifications and the latest edition of the NEBB Standards.

B. Air Handling Unit: Where the term Air Handling Unit (AHU) is used in this spec section, it shall include any factory fabricated or field erected unit that includes a fan and other components which filter, heat, cool, humidify or dehumidify the air stream. But the term AHU, where used in this section, does not include fan powered terminal units, fan coil units, unit heaters, cabinet unit heaters, etc.

C. Air Handling System: A fan or AHU and ductwork.

D. Hydronic System: A system in which a liquid is used to convey heat.

E. Record or Report: Where used as a verb, these terms mean to include in the TAB report.

1.04 QUALIFICATIONS

A. TAB agencies shall meet the following qualifications:

1. Membership in the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or the Testing, Adjusting and Balancing Bureau (TABB).
2. An office located within a 100 mile radius of the project site.
3. A minimum of five (5) years experience in the TAB field.

B. The following TAB Agencies are prior approved:

1. Energy Balance & Integration
2. Kirk Air Co.
3. Native Air
4. N-Demand Test and Balance LLC

1.05 SUBMITTALS

A. Mechanical Contractor shall submit the name of the proposed TAB agency prior to the TAB

agency performing any services.

1. Submit a list of proposed personnel, including resumes with related project experience and certifications.
2. Submit proposed TAB procedures, instrumentation and measurement equipment including calibration data, and proposed sample TAB report forms.

B. Pre-Construction Report: Prior to the Mechanical Contractor installing the systems, the TAB Agency shall submit a letter indicating whether the design includes all devices the TAB Agency will need to successfully perform the TAB work. If any additional balancing devices are needed, the TABB Agency shall so note this in the pre-construction report.

C. Submit TAB reports as noted herein. Reports shall be in both hard copy and PDF format.

1.06 TAB PREPARATION AND COORDINATION

A. Mechanical Contractor shall perform the following in a timely fashion:
1. Provide the TAB Agency with the project documentation (drawings, specifications, bulletins, submittals, shop drawings, etc.) necessary to perform the TAB services.
2. Install, fill, pressure test, start up, clean, and the vent systems to be tested and balanced.

B. Controls Subcontractor shall perform the following in a timely fashion:
1. Install and make operational all necessary control systems and equipment, including computers and computer programs.
2. Provide qualified personnel to operate the systems as necessary to support the TAB effort. Provide the TAB contractor with the computer software necessary to facilitate the TAB effort.
3. Assist as required to resolve problems which become evident due to TAB work, and as required to obtain specified system performance.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Provide all equipment and instruments necessary to perform the work specified herein. Calibrate and maintain instruments per NEBB Standards. Provide not less than the following:
1. Pitot tubes and draft gauges.
2. Flow hood.
3. Velometer.

4. Thermometers.
5. Pressure gauges.
6. Flow meter test kit.
7. Ampere – voltmeter.
8. Speed indicator.
9. Sound meter to measure eight octave bands.

PART 3 EXECUTION

3.01 GENERAL

A. Review and inspect the mechanical systems for conformance with design documents. Test, adjust and balance all system flows under design conditions and under other conditions where part load testing is specified. Comply with measurement tolerances per NEBB. Balance to within 10% of design flows unless otherwise specified.

B. Visually mark the final settings of balancing dampers, balancing valves, fan speed controls, etc.

C. Comply with NEBB Standards. The descriptions included herein are a guide to the minimum information needed.

D. Troubleshooting: In the event that any areas fail to get proper flow, take the lead in troubleshooting the system. Measure pressures, flows, etc. at various points throughout the systems as required to identify the cause of the deficiencies and identify upgrades which will resolve these deficiencies. Coordinate any remedial efforts directly with mechanical and controls contractors and re-test as required.

3.02 TEST AND BALANCE REPORT

A. Report shall be 8-1/2" x 11" bound into a complete and coherent report, except that drawings may be larger size, but still bound into the report. All forms shall be typewritten or legibly handwritten.

B. Include the following sections in the order indicated:

1. Cover sheet with the Project Name, Location, and the names of the Mechanical Contractor and Engineer
2. Table of Contents
3. Summary indicating the highlights of the report and summarizing any deficiencies and recommendations

4. Test results including the names of the persons performing the tests and dates the tests were performed
5. Drawings
6. Description of the test procedures used
7. List of instruments used along with their calibration data
8. Qualifications of personnel

C. Submit five copies and a PDF of the complete TAB report minimum two weeks before the first O&M instruction session. One copy will be returned to the Contractor with review comments.

3.03 BASIC AIR HANDLING SYSTEM TESTING, ADJUSTING AND BALANCING

A. General

1. Test all fans and air handling systems. Balance systems to achieve specified air flows while minimizing throttling losses.
2. Air Flow Measurements: Fan and AHU flow rates may be determined by pitot tube traverse or by measuring fan speed, suction and discharge pressures, and comparison with the fan curve. Measure duct air flows using pitot tube traverses. Measure air flows of grilles, registers and diffusers using either capture hoods or pitot tube traverses in the connected ductwork. Make such other tests as may be required to demonstrate that systems perform per the design requirements.
3. Air Flow Measuring Stations: Calibrate each air flow measuring station which is provided as part of the construction contract. Use duct pitot tube traverses or other appropriate means to measure air flows. Coordinate with the flow measuring station supplier, and enter calibration coefficients into the FMS. Record the results of this effort.
4. Alert Mechanical Contractor and Engineer if any fan or air handling unit (AHU) appears to be operating in an improper or unsafe condition.
5. Seal all test holes in ductwork once testing is complete. Repair insulation jackets to maintain the integrity of the vapor barrier.
6. Include in the report copies of ductwork drawings with test points indicated.
7. Variable Flow Systems: Verify proper fan tracking from full flow to 50% flow.

B. Fans: Perform the following for all fans, including those provided as part of an AHU.

1. Fan Nameplate: Record unit number per the equipment schedule, manufacturer, model, size, and serial number.

2. Performance Data: Measure air flow and adjust fan speed to achieve required flow. Record air flow, static pressure rise and fan speed.
    a. Advise when belt and/or sheave changes are required to achieve the design flows. Mechanical contractor shall make the necessary changes as part of the mechanical contract. Approximately 25% of fans may require a sheave and/or belt change.
3. Current and Voltage: Record motor nameplate and measured voltage and amperage. Advise if motor amps exceed rated load amps.

C. Air Handling Units:
1. Outside Air: Test outside air flows using a pitot tube traverse and balance as required. If a traverse is not practical, use the mixed air temperature method if the inside and outside temperature difference is at least 20 deg F, or use the difference between pitot tube traverses of the supply and return air ducts.
2. Static Pressure: Measure and record the static pressure at the inlet and outlet of each AHU component, including louvers, dampers, filters, coils, etc, and at each inlet and discharge duct connection.

D. Coils: Measure and record air and water flows and pressure drops.

E. Air Distribution Systems:
1. Zone, Branch and Main Ducts:
    a. Adjust to within 10% of design air flows. Balance so that at least one zone balancing damper is wide open. Balance multi-diffuser branch ducts so that at least one outlet or inlet damper is wide open.
2. Air Terminal Units:
    a. Calibrate flow sensors and enter design maximum and minimum flow setpoints into FMS.
    b. Record terminal unit number, size, specified flow, agency measured flow, FMS measured flow, and DDC flow correction factors.
3. Diffusers, Registers and Grilles:
    a. Test, adjust, and balance each diffuser, grille, and register to within 10% of specified design requirements. Record the size of each grille, diffuser, and register, initial flow measurement, and final measured flow.
    b. Where rooms are indicated to be maintained at either positive or negative pressure, balance air flows to achieve these conditions under design flow conditions, and

verify proper pressurization at minimum flow.

F. Fan Coil Units, Unit Heaters, Cabinet Unit Heaters, Air Curtains, Door Fans, Fan Powered Terminal Units and other devices with fans and coils:
   1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
   2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.
   3. Measure and record initial and final water flows and pressure drops.

G. Energy Recovery Units:
   1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
   2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.

3.04 HYDRONIC SYSTEMS

A. General:
   1. Prior to commencing hydronic balance:
      a. Set valves to proper position per the sequence of operation. Open all coil valves to full open position. Set 3-way valves to full flow through system component.
      b. Check pump rotation.
      c. Verify that system is adequately pressurized.
      d. Set temperature controls so all system components deliver maximum flow.
      e. Balancing may be done in sections.
   2. Pumping Systems: Measure flows and determine operating characteristics of hydronic systems with pumps operating both independently and in parallel (where applicable). Make measurements at maximum flow.
   3. Balance systems to minimize throttling out in the distribution, and to instead throttle at the pump discharge. Recommend impeller trimming if appropriate.
   4. Measure and report performance readings on all pumps, coils, heat exchangers, heating and cooling water generating equipment, flow measurement devices, heat rejection equipment, etc. Measure and record the following for each item of hydronic equipment:

Eqpt Type		Pumps (Note 1)	Chillers	Air Cooled Condensers	Cooling Towers	Hot Water Boilers	Steam Boilers	Heat Exchangers	Coils			
Tag No.		X	X	X	X	X	X	X	X			
Nameplate Data	Mfgr	X	X	X	X	X	X	X	X			
	Model	X	X	X	X	X	X	X	X			
	Serial	X	X	X	X	X	X	X	X			
	Volts	X	X	X	X	X	X					
	RPM	X	X	X	X	X	X					
	HP	X			X							
	FLA	X	X	X	X	X	X					
	Refrigerant		X	X								
Scheduled	GPM1	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2		X					X				
	Press Drop		X					X				
Measured	GPM1	X	X		X	X		X	X			
	Inlet Press	X	X		X	X		X	X			
	Outlet Press	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2	X	X					X				
	Inlet Press	X	X					X				
	Outlet Press	X	X					X				
	Press Drop	X	X					X				
	Volts	X	X	X	X	X	X					
	Amps	X	X	X	X	X	X					

Notes

1 For pumps measure pressure rise instead of pressure drop. Measurements for GPM2 shall be at shutoff conditions.

5. Domestic HW return system: Balance to ensure HW availability throughout the system. Where balancing valves are provided, record flow and balance to provide flow in each circuit.

3.05 LIMIT DEVICES AND SAFETY CONTROLS

A. Limit Devices: Check all limit devices to verify proper operation, including, freezestats, flow switches, etc. Include in the TAB report a list of all such devices and the results of their tests.

B. Fire and Smoke Dampers

1. Test each fire damper, smoke damper, and fire/smoke damper to ensure proper operation. Record test results.

2. Fire Dampers: Open access door, disconnect fusible link or activate thermal link, and

verify that damper closes smoothly and completely. Reset damper and access door.

3. Smoke Dampers: Open access door, activate damper, observe whether it closes smoothly and completely, and measure closing time. Reset damper and verify it opens completely. Close access door and record test results.

C. Life Safety Controls: Test and record life safety control operation of the HVAC systems. Verify the installation of required smoke detectors in air handling equipment, and verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown or other required functions as described on the control drawings and sequence of operation. With assistance from the contractors for mechanical, temperature controls and electrical work, verify the operation of interconnected systems, such as the smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequence.

END OF SECTION

SECTION 23 0700 - MECHANICAL SYSTEMS INSULATION

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.02 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 3000, Air Tempering System and Equipment.

1.03 SCOPE

A. Field insulation of piping: see drawings and Part 3 of this specification.

B. Field insulation of ductwork: See drawings, Table 23 0700-1, and Part 3 of this specification.

C. Field insulation of equipment supplied and/or installed under Division 23: See drawings and Part 3 of this specification.

D. Factory-insulated equipment and materials are described on the equipment schedule, on the drawings, and in other sections of this specification.

1.04 SUBMITTALS

A. Submit products to be used including insulation, jackets, miscellaneous products, and products for special applications. Review each application and advise if any product is either not suitable for, or not recommended for the application.

B. Verify that each submitted product meets all requirements for that product as specified herein. Include literature that clearly shows products meet all aspects of the spec. Include a cover sheet or letter with the following statement:

> "Each product submitted here meets all specified requirements for that product except as follows:" followed by a list of any discrepancies.

C. Submit schedules showing the type of product and thickness for each application. Indicate products to be used on valves and fittings. Indicate where vapor barriers will be provided and what jackets will be used.

D. D-5, D-6 & D-7 insulation: If one of these insulations is specified, submit documentation indicating that the submitted materials are approved for the intended service.

E. Submit a description of the application techniques to be used.

1.05 QUALITY ASSURANCE

A. Comply with the latest edition of the National Commercial & Industrial Insulation Standards, as published by the Midwest Insulation Contractors Association.

B. Part 3 and Table 23 0700-1 give the system temperatures for various applications. Supplier shall review these temperatures and confirm the suitability of all components for the specified applications.

C. Test piping and ductwork in accordance with applicable specification sections before insulation is applied.

PART 2 PRODUCTS

2.01 GENERAL

A. All materials must be 100% asbestos-free and 100% formaldehyde-free, NO EXCEPTION.

B. All materials must be GreenGuard Gold Certified.

C. Smoke and Fire Ratings: All materials shall have a composite fire and smoke hazard rating not exceeding flame spread 25, fuel contribution 50, smoke developed 50, when tested as assemblies per ASTM Standard E-84 or NFPA 255.

D. Thermal conductivities: Per ASTM C518. Do not exceed the conductivities indicated. Units listed herein for conductivity are Btuh-in/SF-F. Resistance shall not be less than the values specified herein. Units for resistance are SF-F/Btuh.

E. Noise Reduction Coefficients: Per ASTM C423 based on Type A mounting. NRC shall not be less than as specified.

F. Jackets: Maximum 0.02 perm water vapor transmission per ASTM E96 Procedure A.

1. ASJ: All service jacket per ASTM C1136 Type I, paintable white kraft paper outer surface reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal lap and butt strips, breach puncture min. 50 oz-in/in tear per ASTM D781, tensile strength min. 30 lb/in per ASTM D828.

2. FSK: Foil skim kraft per ASTM C1136 Type II.

G. Fiberglass insulation: Inorganic fibers bonded with thermosetting resin.

H. Approved Manufacturers: Owens Corning, Johns Manville, Knauf, Certain-Teed, Kflex, Armacell, Unifrax -Insulfrax, Industrial Insulation Group, Pittsburgh Corning. Where the term OAE is used herein, this refers to these manufacturers only. No other manufacturers are approved for this project.

2.02 PIPE INSULATION

A. General

1. Valves, Fittings, and Accessories: Use the same insulation materials and thickness as the pipe insulation, except as noted.

B. Type P-1, Fiberglass Pipe Insulation: Factory assembled insulation and ASJ. Pre-formed fiberglass per ASTM C547 Type I, suitable for use on surfaces from 0–850°F, with thermal conductivity 0.23 at 75°F or 0.33 at 250°F, and minimum 3 pcf density. ASJ shall have self-sealing lap at end and along length, with pressure sensitive tape lap sealing system. Owens Corning SSL II Pipe Insulation, Johns Manville Micro-Lok, Knauf Pipe Insulation.

1. Where Type P-1 insulation is used, insulate fittings, valves and accessories using one of the following:

a. Fiberglass pre-formed fitting insulation complying with the specification for P-1 pipe insulation, Johns Manville Hi-Lo Temp insulation inserts, Hamfab, OAE. Finish with Type J-2 fitting covers.

b. Where pre-formed fitting insulation is not available, the following may be used: minimum 0.75 pcf density fiberglass per spec for D-1 insulation except without FSK. Finish with Type J-2 fitting covers or with two coats of fitting mastic with fiberglass fitting tape embedded between coats.

C. Type P-2, Fiberglass Pipe and Tank Insulation: Similar to Type P-1 insulation and jacket, except with fibers oriented to allow insulation to be wrapped onto curved surfaces, with conductivity 0.30 at 100°F, or 0.55 at 400°F. Johns Manville Pipe & Tank Insulation, Owens Corning Pipe and Tank Insulation or Knauf Pipe and Tank Insulation.

1. Alternate: Fiberglass board insulation similar to Type D2, scored for application on curved surfaces, with ASJ.

D. Type P-3, Calcium Silicate Pipe Insulation: Rigid calcium silicate per ASTM C533, Type 1, asbestos-free, suitable for use on piping up to 1200°F, conductivity 0.55 at 700°F, compressive strength min. 200 psi at 5% compression. Industrial Insulation Group OAE.

1. Fittings, valves and accessories: Insulate with mitered Type P-3 insulation or Type D-7 insulation.

E. Type P-4, Elastomeric Foam Pipe Insulation: Pre-formed elastomeric foam, ASTM C534 Type 1 flexible, closed cell, suitable for use up to 220°F, UV protected, not to exceed flame spread 25 and smoke developed 50 based on 0.75-inch thickness, conductivity 0.30 at 75°F. Kflex, Armacell OAE.

1. Fittings, valves and accessories: Insulate using either Type P-4 insulation pre-formed for use on fittings and valves, or cut sections of P-4 pipe insulation to match the shape of the fitting or valve, taped on using PVC tape.

2.03 DUCTWORK INSULATION

A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250°F, 3/4 pcf fiberglass, ASTM C553 Type I or II, with thermal resistance not less than the following for 2-inch thickness: 6.8 out of the box, 5.6 installed with 25% compression. Johns Manville Microlite XG Duct Wrap, Owens Corning Soft R Duct Wrap, Knauf Friendly Feel Duct Wrap, Certainteed Soft Touch Duct Wrap.

B. Type D-2, Fiberglass Board: Similar to Type D-1 except rigid board type, 3 pcf density, thermal conductivity 0.23 at 75°F, NRC 1.36, suitable for unfaced side at up to 450°F and faced side at up to 150°F. Johns Manville 800 Series Spin Glas, Owens Corning 700 Series Board, Knauf Insulation Board, Certainteed Certra Pro Commercial Board

C. Type D-3, Acoustic Lining (roll type): Organic fiber or fiberglass duct liner bonded with thermosetting resin, with factory-applied acrylic surface coating treated with anti-microbial agent, and factory-applied or shop-applied edge coating.

1. Properties: Minimum 1.5 pcf density, thermal conductivity 0.24, 6000 FPM rated per UL 181, NRC 0.70 at 1-inch thick and .95 at 2-inch thick. The product (fiberglass, resin, coating, microbial agent and adhesive) as an assembly shall be suitable for surfaces and gases up to 250°F, and shall comply with ASTM C1071 (Type I), G21 and G22.
2. Lining surface shall be cleanable using commercially available duct cleaning equipment when performed by qualified technicians using procedures established and recommended by the North American Insulation Manufacturer's Association (NAIMA) Duct Cleaning Guide.

3. Johns Manville Linacoustic RC, Owens Corning Acoustic R duct liner, Knauf EM duct liner, Certainteed ToughGuard R Duct Liner.

D. Type D-4, Acoustic Lining (board type): Similar to Type D-3 and complying with all aspects of the spec for Type D-3 insulation, except 3 pcf density rigid board with NRC 0.75 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Permacote Linacoustic R-300. Owens Corning Duct Liner Board, Knauf Rigid Plenum Liner, Certainteed Rigid Liner Board.

E. Type D-5, Grease Duct Applications: High temperature, foil-encapsulated inorganic blanket, 8 pcf. Insulfrax Fyre Wrap Max 2.0, Johns Manville Fire Temp, OAE. Product shall meet the following when applied as 2-layers around a grease-duct:

1. Tested and listed for zero clearance to combustibles across the entire surface of the blanket material per internal fire test AC101 or ASTM E2336 - Internal Fire Test – 2 Hr Grease Duct Enclosures.
2. Rated as a 2-hr fire resistive enclosure assembly per ASTM E-119, Engulfment Fire Test for 2-hr Grease Duct Enclosure.

F. Type D-6 –Combustible Materials within Plenum: For use on combustible materials located within supply or return air plenums, foil-encapsulated 8 pcf high-temperature ceramic fiber blanket suitable for service up to 1800^{o}F. Unifrax Fyre-Wrap 0.5 plenum insulation.

G. Type D-7 – Fire Rated Ductwork: Suitable for continuous operation at 1800^{o}F, 6-pcf, foil-encapsulated inorganic blanket to provide a 2-hour rating per ISO 6944 when applied in a single 1.5-inch thick layer. Insulfrax FyreWrap 1.5 OAE.

H. Type D-8 – Polystyrene Insulation: Rigid cellular square edge insulation per ASTM C578, waterproof, thermal conductivity 0.20, compressive strength 25 psi. Dow Styrofoam or Owens Corning Foamular.

I. Type D-9 – Fiberglass Ductboard: Listed per UL 181 as a Class 1 Rigid Air Duct; conforming to ASHRAE Std. 62, NFPA-90A and 90B, ASTM G-21 & G-22; rated for 2-in. wg; constructed of fiberglass bonded with a thermosetting resin, with double density slip joints pre-molded in the board; FSK jacket; thermosetting acrylic polymer interior surface, and black interior surface color. Thermal conductivity 0.23, and NRC 0.70 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Superduct 475 or 800, Owens Corning Quiet R Duct Board, Knauf Duct Board M, Certainteed ToughGard Duct Board

2.04 EQUIPMENT INSULATION

A. E-1, Removable Insulating Blanket: Factory fabricated, one-piece, removable and re-usable insulating blanket with fiberglass insulation completely enclosed within a silicone coated fiberglass cloth with draw cords of SS or PTFE coated glass fiber, and stainless steel clips. Insulation thickness shall be as specified elsewhere, but not less than 1-inch. Energy Systems Inc. "Q-Master" OAE.

2.05 INSULATION JACKETS

A. Type J-1, Metal Jacket: 0.010-inch smooth Type 304 stainless steel or 0.016-inch smooth or embossed aluminum per ASTM B-209, with minimum 1-mil polyethylene film with protective layer of 40 Lb virgin kraft paper, continuously laminated to full width inside jacket. Childers OAE.
   1. Where jacket diameter is 16–96 in: 0.016-in. SS or 0.020 in. aluminum.
   2. Equipment heads and all surfaces where jacket is greater than 96-inch OD: 0.020-inch SS or 0.024 inch aluminum.
   3. Fittings and Accessories: Provide the same jacket material as for pipe.

B. Type J-2, PVC Jacket: Minimum 20 mil sheets and 30-mil pre-molded fitting covers, ASTM D1784, Class 16354-C. Accessories include solvent weld solution, stainless steel tacks, and tape. All components shall be white, UV resistant, with paintable exterior surface, and suitable for use at –20 to +150ºF. Johns Manville System 2000 (sheets), Zeston 300 (fitting covers), and Perma-Weld (solvent cement), OAE.

C. Type J-3, Canvas Jacket: 10 x 10 fiberglass mesh.

2.06 MISCELLANEOUS PRODUCTS

A. General:
   1. Tapes: Aluminum, pressure sensitive, UL 181A-P listed and embossed, minimum 2.5-inch wide, Nashua 324A OAE.
   2. Duct Liner Adhesives: Water-based, complying with ASTM C916.
   3. Solvent Cement for PVC Jackets: Johns Manville Perma-Weld OAE.
   4. Staples: Outward clinching, 0.5-inch galvanized steel

B. Piping Systems:

1. Pipe Hanger Insulation Inserts: Mechanical Pipe Shields Inc. “Snapp Itz” OAE.

C. Ductwork Systems:

1. Duct Liner Edge Sealer, Surface Sealer, Coatings & Adhesives: To meet ASTM C916. Johns Manville Superseal OAE.

2.07 SPECIAL APPLICATIONS

A. Handicap Lavatory Insulation Kit: Handi-Lav-Guard insulation kit per ANSI A117.1 with flexible vinyl finish.

PART 3 EXECUTION

3.01 GENERAL

A. Delivery, Storage and Handling: Deliver and store insulation materials in factory-supplied containers. Protect from moisture. Do not install any materials that have gotten wet, regardless whether they are subsequently dried.

B. Store and apply materials in accordance with manufacturers’ recommendations, but not less than the following minimum temperatures. Ensure surfaces are clean and dry prior to application, and for minimum two hours after application:

1. Sealers, coatings, solvents and adhesives: 40^{o}F.

2. Tapes 50^{o}F.

C. Install in accordance with manufacturer’s recommendations, NAIMA recommendations, and this spec. Provide good ventilation.

D. Where vapor barriers are specified, ensure that the entire system is vapor sealed.

E. Protect materials from water damage. Replace any materials that are water-damaged prior to substantial completion.

3.02 PIPING INSULATION

A. General: Insulate piping as indicated herein and/or on the drawings. Except as noted, insulate all valves, fittings, and accessories with the same material and thickness specified for the pipe. Where piping is specified with a separate insulation jacket provide this same jacket for valves, fittings and accessories. Vapor seal cold piping systems.

1. Where insulation terminates, provide insulating cement beveled for a neat finish. For vaporsealed piping, coat with insulating mastic prior to applying insulating cement.

2. Strainers and Suction Diffusers: Either Type P-1 or P-3 insulation. Make provisions to easily remove and re-install insulation.
3. Pipe Supports: Provide high density calcium silicate insulation or insulation inserts as specified. Maintain pipe jacket and vapor barrier at supports. If necessary, apply a heavy coating of vapor barrier mastic material to prevent condensation from forming on supports. Provide galvanized steel insulation shields to protect insulation and jackets at supports.
4. Penetrations Through Building Construction: Insulation shall be continuous where piping passes through walls, floors, and other construction. Where insulated piping passes through fire and/or smoke rated construction, provide a section of UL approved fire safing insulation to match the required insulation thickness, or provide an insulated pipe sleeve as manufactured by Pipe Shield, Inc., OAE.
5. Mechanical Couplings: Where mechanical couplings are permitted, insulate them as specified for fittings.
6. Steam Traps: Do not insulate.
7. Retrofit Projects: Match the thickness of existing insulation where new insulation adjoins existing. Integrate new vapor barrier with existing so the insulation barrier is continuous for both new and existing piping.
8. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

B. Application:

Temp Range	Temp (F)	Insulation Type	Vapor Sealed	Pipe Size				
				< 1	1 to 1-1/4	1.5 to 3	4 & 6	≥ 8
TR-1	< 40	P-1 or P-4	Yes	0.5	1.0	1.0	1.0	1.5
TR-2	40-60	P-1 or P-4	Yes	0.5	0.5	1.0	1.0	1.0
TR-3	61 – 104	P-1	Yes	0.5	0.5	0.5	0.5	0.5
TR-4	105 - 140	P-1	No	1.0	1.0	1.5	1.5	1.5
TR-5	141 - 200	P-1	No	1.5	1.5	2.0	2.0	2.0
TR-6	201 - 250	P-1	No	2.5	2.5	2.5	3.0	3.0
TR-7	251 - 350	P-1	No	3.0	4.0	4.5	4.5	4.5
TR-8	Over 350	P-1	No	4.5	5.0	5.0	5.0	5.0

1. Temperature Range TR-1: Chilled water (Glycol)
2. Temperature Range TR-2: Chilled water, refrigerant suction, condenser water (outdoor piping subject to freezing).

3. Temperature Range TR-3: Domestic cold water, makeup water, soft water, industrial water, process water of any type, non-potable water, HVAC make-up water (except insulation is not required for evap cooler makeup piping outdoors), interior horizontal roof drain and overflow bowls and piping, condensate drains indoors.
4. Temperature Range TR-4: Domestic hot water (including non-circulating HW within interior walls and chases) and domestic HW return except as noted.
5. Temperature Range TR-5: Heating water supply and return, low pressure steam condensate, pumped condensate return, engine cooling water.
6. Temperature Range TR-6: Low pressure steam, boiler feedwater, boiler surface blowoff, medium and high pressure steam condensate return.
7. Temperature Range TR-7: Steam at 16 - 120 psi.
8. Temperature Range TR-8: Steam above 120 psi.

C. Special Applications
1. Handicap Lavatories: Insulate domestic hot and cold water piping and P-traps exposed below handicapped lavatories with insulation kit specifically designed for the application.
2. Heat Traced Piping: Oversize insulation as required to accommodate heat tracing. Provide metal jacket.
3. Piping subject to freezing and heat traced piping: Insulate all such piping (including drain piping) with thicknesses specified, but not less than 1.5-inch thickness. Oversize insulation to accommodate heat tracing where indicated. Provide J1 jacket.

D. Type P-1 & P-2, Fiberglass Insulation: Install in accordance with manufacturer's recommendations.

E. Type P-3, Calcium Silicate Insulation: Adhere to pipe or equipment using stainless steel wire. Provide removable J-1 jacket.

F. Type P-4, Elastomeric Foam: Seal all butt ends and longitudinal joints with Halstead Adhesive. When exposed to the weather, protect flexible tubing insulation with two coats of exterior weatherproof coating as recommended by manufacturer.

G. Jacketing: In addition to the finish and jacket specified for the particular type of insulation, provide the following:
1. Indoor piping exposed to physical damage Type J-2, PVC
2. Mechanical Eqpt Spaces: Exposed piping
less than 8 ft above floor or operator platform Type J-2, PVC

3.03 DUCTWORK INSULATION

A. General:

1. Insulate all ducts except those specified to be uninsulated. The following ductwork need not be field insulated:
    a. Factory insulated ductwork and plenums.
    b. Ducts with acoustic lining, provided the lining thickness matches or exceeds the required insulation thickness.
    c. Exhaust ducts, except where noted.
    d. Return air ducts, except where noted.
2. See Table 23 0700-1 for additional information.
3. Ensure that ductwork is leakage tested prior to applying insulation. Inspect ductwork and repair any deficiencies prior to applying insulation. Do not apply insulation over deficient ductwork or plenum construction.
4. Ensure that ductwork is clean and dry before applying insulation.
5. For ductwork with acoustic lining the drawings indicate the "clear inside duct dimension" required. Over-size ducts as required to provide the required air flow area.

B. Type D-1, Fiberglass Blanket Insulation: Measure and cut insulation. Install so insulation is not excessively compressed at corners. For rectangular and flat oval ducts 24-inches and wider, provide stick pins and speed clip washers 18-inches on centers on the bottom, and clip off excess length of stick. Firmly butt insulation ends and longitudinal joints. Overlap jacket minimum 2-inches at end joints and longitudinal joints, staple on 6-inch centers, and continuously seal jacket. Provide vapor barrier mastic where ducts are indicated to be vaporsealed. Should gaps or fishmouths occur, re-staple and seal them with mastic. Use FSK tape and vapor barrier mastic to seal all penetrations of the FSK jacket, such as pins, tears, and hangers. Neatly trim and seal insulation at access doors, ends, damper rod controls etc. Verify proper damper operation.

C. Type D-2, Fiberglass Board Insulation: Attach with mechanical fasteners 12" on centers.

D. Type D-3 & D4, Acoustic Lining: Ductwork dimensions indicated on the drawings are net air flow dimensions inside liner. Increase duct size to accommodate liner. Completely line the inside surfaces of ducts and plenums specified and indicted. Comply with the NAIMA Fibrous Glass Duct Liner Standard (FGDLS), manufacturer’s recommendations, and this spec. Adhere liner with minimum 90% coverage of adhesive, and secure with mechanical fasteners and

washers per FGDLS and manufacturer's recommendations. Fastener length shall be sufficient to limit compression of liner to 1/8" maximum. Coat all cut edges and surface penetrations with edge sealer. Provide metal nosing for liner leading edges at fan discharge and for all ducts with air velocities exceeding 3,000 FPM. Maintain minimum 18-inch clearance from electric resistance heaters. Interrupt liner at dampers and apply external insulation at these locations.

1. Provide Type D-3 insulation for the 10 feet upstream of roof exhaust fans except in wet air streams.

E. Type D-5: Install insulation in a 2-layer system per manufacturer's instructions, including the use of mechanical fasteners for the underside of ducts, butting or overlapping of joints, and offsetting of joints on outer layer.

F. Type D-6: Install in accordance with manufacturer's instructions. Overlap seams and joints minimum 2-inches, affix with SS wire minimum 18-inches on centers, but not less than per manufacturer's recommendations, and tape seams and joints with aluminum tape.

G. Type D-7: Install insulation in a single-layer system per manufacturer's instructions. Mechanical fasteners for the underside of ducts shall be adhered to the duct in a manner suitable for the operating temperatures (welded or other suitable method). Butt or overlap joints per manufacturer's recommendations.

H. Type D-8: Wire in place with SS wire minimum 12-inches on centers, and provide J-1 jacket.

I. Type D-9: Install per manufacturer's recommendations, NAIMA standards, and SMACNA Fibrous Glass Duct Construction Standards. Provide ship lap seams and joints.

3.04 EQUIPMENT INSULATION

A. General: Where specified elsewhere, equipment will be factory insulated. Insulate all equipment as noted herein except portions of equipment that are factory insulated.

1. Fiberglass Board Insulation: Score, bevel, or miter to provide tight joints and secure in place with mechanical pin and clip fasteners and insulation bonding adhesive applied to underside surfaces, or with bands. Fill joints with insulation material and provide corner beads to protect edges of insulation.
2. Cold Tanks and Equipment: J3 jacket with two coats of approved vapor barrier mastic.
3. Factory Packaged Equipment: Field insulate the equipment and piping on factory-fabricated assemblies as if they were field installed, unless such items are factory insulated.

3.05 JACKETING

A. Type J-1, Metal Jacketing:
   1. Ducts: Slope jacketing to shed rain.
   2. Pipes: Install with seams at the 3 o'clock or 9 o'clock position to shed water. Band 12" on centers.
   3. Joints and Seams: Overlap joints minimum 2-inches. Caulk with a weatherproof caulk when located outdoors.

B. Type J-2, PVC Jacketing: Secure in place with tacks and solvent welded joints. White PVC tape may be used indoors.

C. Type J-3, Canvas Jacket: Apply mastic at a rate of 60 to 70 sq. ft. per gallon, embed fiberglass mesh, smooth all wrinkles and apply finish coat of Sealfas, or equivalent.

END OF SECTION

TABLE 23 0700-1 – DUCTWORK INSULATION

Service	Location	Condition	Insulation Type	Insulation Thickness (in)	Notes
Supply Air, Makeup Air, Outside Air	Indoor	Concealed	D1	2.0	1, 6
Supply Air, Makeup Air, Outside Air	Indoor	Exposed	D2	2.0	
Supply Air, Makeup Air, Return Air	Outdoor	All	D8	2.0	2, 4, 7
Supply Rectangular Ductwork downstream of Terminal Units, Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	2.0	1, 3
Return Rectangular Ductwork upstream of Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	1.5	3
Ductwork indicated to be lined	All	All	D3	1	5
Ductwork indicated to be lined with 2-inch acoustic lining	All	All	D3 or D4	2	5
Single Wall Lined Plenums	All	All	D4	2	
Transfer Air Ducts	All	All	D3 or D9	1	
Exhaust Ductwork	Indoor	Concealed	D1	1.5	8
Exhaust Ductwork	Indoor	Exposed	D2	1.5	8
Kitchen Exhaust Ductwork	Indoor	All	D5	2-layers	
Plastic Piping and Ductwork within RA Plenums	Indoor	Concealed	D6	0.5	
Fire-Rated Ductwork Other than Kitchen Exh	Indoor	All	D7	1.5	
Boiler Breeching & Stack	Indoor	All	P1 or P2	3	
Boiler Breeching & Stack	Outdoor	Exposed	P1 or P2	3	4, 7

Notes:

1 Includes Supply Air Duct from Energy Recovery Units and Evaporative Coolers.
2 Provide acoustical liner as indicated on the drawings.
3 In general, insulation is not required on return ductwork if located in an indirectly conditioned space such as a ceiling plenum space. Provide type D3 insulation in duct if indicated to be lined on the plans or installation details.
4 Provide J1 Jacket.
5 In hospitals do not provide acoustical lining in supply ductwork or plenums downstream of the final filter.
6 Vaporseal ducts conveying cold air.
7 Seal outdoor ductwork to prevent ingress of moisture.
8 Insulate only the portion of exhaust ductwork between isolation damper and outside.

SECTION 23 0900 - AUTOMATIC TEMPERATURE CONTROLS

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Special Conditions and the General Requirements.

1.02 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.
B. Section 23 0505, Piping Specialties.
C. Section 23 0523, Valves.
D. Section 23 0549, HVAC and Electrical Installation Coordination.
E. Section 23 0593, Testing, Adjusting and Balancing.

1.03 SCOPE

A. It is the intent of this section to provide a fully functional system to provide fully automatic temperature control for all systems provided under this contract.
B. It is the responsibility of the bidder to read and conform to all sections of the specifications, review all contract drawings and to coordinate all equipment supplied under other sections of the specifications with this work.
C. The control system shall include all operator input/output devices, field control units, field controls, sensors and controls conduit, wiring, and piping, etc.
D. The engineering, installation supervision and labor, calibration, and checkout necessary for a complete and fully operational control system as specified hereafter shall be provided under this section.
E. The controls contractor shall be responsible for installation of factory furnished and field installed controls as well as all other system controls indicated on the contract drawings or required by this specification.

1.04 PRIOR APPROVAL

A. The controls contractor must be engaged in the business of installation and service of controls systems on a regular basis and must have at least five years experience. Mechanical or electrical sub-contractors will not be accepted as the controls system installer. The controls system installer shall employ full time factory trained and qualified service staff to support and maintain the controls system.

1.05 SUBMITTALS

A. Submittals shall be provided as required by 23 0500 and the General Contract Requirements. Submittals shall consist of shop drawings and catalog data sheets. Shop drawings shall show all controlled devices, electrical ladder diagrams, system schematics, sequence of operation, and material lists.

B. Within 30 days of contract award, submit eight sets of shop drawing and submittal data. These submittals shall be provided to the Mechanical and Electrical sub-contractors for co-ordination review and evaluation prior to being submitted to the Owner's authorized representative. Letters from these sub-contractors verifying that they have reviewed the submittals and including any comments must be attached with submittals when submitted to Owner's authorized representative. Submittals received without such reviews will be returned without action.

1.06 SHOP DRAWINGS

A. Shop drawings shall be provided which show all controlled systems and control devices. Connections between all components shall be clearly indicated. Control contractor shall coordinate with other suppliers prior to submitting so that final connections to all equipment can be shown. Simply showing a connection with no identification or termination will be considered unacceptable. All connections shall be labeled on both ends and these same labels shall be used for the installation process. Each device shall also be given a unique identifier. This identifier shall be used in the sequence of operation so that reference to the drawings can be easily made.

B. Electrical Ladder Diagrams shall be provided on the shop drawings which show the correct control wiring and interlock wiring of all equipment provided by Division 23 and other equipment required including air handling units, boilers, chillers, etc. including owner furnished

equipment and equipment under other sections of this specification. Diagrams shall show all switches, relays, motor starters, etc. Each diagram shall reference the correct power source, whether from a specific circuit or from a control transformer. If equipment shown is provided by another contractor, then this shall be noted. Any relevant set points, such as time delay relay settings, shall be shown.

C. The sequence of operation for each controlled system shall be provided with reference to the control device identifier. The sequence of operation shall break down the control operation by major function (i.e., mixed air control, occupied-unoccupied, smoke purge, etc.) and describe in detail the correct operation and interaction with other system functions.

D. A complete material listing shall be included on the shop drawings which show the device model number, device identifier, quantity, manufacturer, etc., of all equipment provided by this contractor. The material list shall be organized in alphabetical order so that it can be easily compared to the associated catalog data sheet. The quantities are to be provided only to confirm a general understanding of the contract requirements and will not be verified as a complete material list.

1.07 CATALOG DATA SHEETS

A. A manufacturer's catalog data sheet will be provided for each piece of equipment provided by this contractor. At a minimum, the data sheet shall contain sufficient information so that compliance with the specification can be verified. The catalog data sheets shall be organized in alphabetical order to match the material listing on the shop drawings.

1.08 RECORD DRAWINGS

A. Record drawings shall be provided as required by 23 0500 and the General Contract Requirements. Record drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded on the submittal drawings so that a current record drawing is constantly being updated. At completion of the project, all changes shall be incorporated into a clean record drawing version. These record drawings shall be detailed enough to thoroughly trouble-shoot the entire system.

B. With the reproducible record drawings the Contractor shall furnish a complete spare parts lists, operating instructions, and maintenance literature, for proper maintenance of all control equipment, in accordance with the requirement specified in Section 23 0500.

C. The following manuals or combination manuals will be provided 2 sets:
   1. An operator's manual which will include detailed instructions for all operations associated with the Automatic Temperature Controls System.

1.09 TEST AND INSTRUCTION

A. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to and during functional performance testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   1. System name.
   2. List of devices.
   3. Step-by-step procedures for testing each controller after installation, including:
      a. Process of verifying proper hardware and wiring installation.
      b. Process of performing operational checks of each controlled component.
      c. Plan and process for calibrating valve and damper actuators and all sensors.
      d. A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
   4. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
   5. A description of the instrumentation required for testing.
   6. Indicate what tests on what systems should be completed prior to Testing, Adjusting and Balancing (TAB) using the control system for TAB work. Coordinate with the Owner and TAB contractor for this determination.

B. Upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, provide a signed and dated certification to the Owner and GC that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

C. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air and water pressure).

D. At the termination of the testing period, the Contractor shall provide completed point verification sheets for each point in the FMS. These sheets shall be included as a part of the closeout notebook. An example of a point verification form is included in the appendix.

E. The Owner reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to the Owner.

1.10 TRAINING

A. Upon completion of the work and acceptance by the Owner, factory representatives under employment of the ATC supplier shall provide 8 hours total of on site instruction to the Owner's operating personnel who have responsibility for the mechanical system.

1.11 SERVICE AND WARRANTY

A. The system supplier shall maintain a local maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24-hour, 7-day a week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service and this number shall be provided to the Owner.

B. Warranty all work as follows:

1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. Service during this period shall be available within 12-hours from the time the trouble call is placed.

2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.

C. Service and maintenance must be provided for one year minimum from time of owner acceptance of the pneumatic system with 12-hour response time. Warranty shall be for full system component parts and labor.

1.12 PROGRESS PAYMENTS

A. When developing a schedule of values for the FMS and control systems, a minimum of 20% shall be reserved for activities after construction completion, including commissioning support, testing (functional performance testing and trend logs as required herein), record drawings, training, etc. Payment for these activities may be requested as they are completed.

PART 2 PRODUCTS

2.01 GENERAL

A. All products required for this project not provided with the factory controls systems shall be selected in accordance with this Part of the Section. Installation of the components shall be in accordance with Part 3 of the Section. If a component is required to meet the requirements shown on the drawings and is not specified in the Part of the specification, the Supplier shall select and submit on components that meets all design requirements indicated on the Drawings, stated in the sequence of operation, and elsewhere in the Contract documents.

2.02 ROOM THERMOSTAT AND OCCUPANT CONTROLS

A. Electronic Programmable Thermostat (Multi-Stage): Electronic programmable thermostats shall be fully configurable single piece commercial design with sub-bases provided for required application. Supply voltage shall be 20-30 VAL with a maximum power consumption of 6 VA. Output relays for fan, heat, cool, and economizer shall all be rated for 1.6 amps running and 3.5 amps in rush. Programmable temperature range shall be 45^{o}F to 95^{o}F and schedules shall be programmable to ten minutes. Shall be capable of two occupied and two unoccupied intervals per day. Control shall be from a proportional-integral loop with intelligent fan and recovery control. Occupancy override button shall be located on the thermostat to allow for two hour override of the occupied mode.

B. Electronic Thermostats: All space thermostats shall be self contained fully proportional solid state units operating on a maximum voltage of 24 VAC or 24 VDC. The thermostats shall have one exposed and adjustable setpoint adjustment with a range of 55^{o}F to 85^{o}F. A compatible proportional output shall be to drive the associated actuator. Where sequenced proportional and digital devices are indicated, solid state staging relays shall be provided to operate the digital equipment at an adjustable pick-up point on the proportional output signal. The thermostat

cover shall be constructed of beige plastic and shall operate in an environment of 40°F to 135°F and 5 to 95% relative humidity. The thermostat shall be rated at NEMA I.

C. Line Voltage Thermostat: The thermostat shall be of the bimetallic design with a SPDT set of contacts rated for 120 VAC at 25 amps. Thermostat shall have an adjustable set point of from 50 deg F to 86 deg F with a fixed differential of 2.0 deg F.

2.03 CONTROL RELAYS

A. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contracts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.

2.04 SMOKE AND FIRE DETECTORS

A. Smoke detectors shall be supplied, powered, installed, and interlocked in accordance with Section 23 0549. The smoke detectors shall be listed by Underwriters' Laboratories, Inc. The units shall be designed for detection of combustion gases, fire and smoke in air conditioning and ventilation system ducts, in compliance with the National Fire Protection Association, Recommended Practices Pamphlet No. 90A. It shall consist of an ionization type detector with self-contained control unit. The assembly shall consist of a casting to accommodate metallic sampling tubes which extend across the duct of the ventilation system.

B. The unit shall provide two (2) sets of normally open single pole, double throw alarm operated relay contacts (5A, 120V, AC).

C. The unit shall be bolted directly to the duct or plenum wall. A template shall be provided for making necessary cutouts and holes. Complete instructions shall be provided with units.

D. Unit shall be capable of stable operation from 0 deg to 150 deg F.

E. Sampling tubes shall be EMT tubing, 1/2-inch in diameter, length and support as required to extend across plenum or duct. Quantity and location of sampling tubes shall be as required for representative sampling. Plastic tubes will not be allowed.

2.05 WIRING

A. Provide interlock wiring between supply and exhaust fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring

between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Provide interlock wiring between boilers and pumps as required for the specified sequence of operation and the hot water system integral controller(s).

B. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by the factory controls and field installed.

C. Provide all other wiring required for the complete operation of the specified systems including control power wiring not expressly stated to be provided by Division 26.

D. Install all wiring raceway systems complying with the requirements of the National Electrical Code and Division 26. All installations shall be installed in EMT.

E. Power and Communication Wiring Transient Protection

1. The control manufacturers shall submit catalog data sheets providing evidence that all FMS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.

2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General Semiconductor, Model #422E device.

3. The communications circuitry, input/output circuitry, and CUs, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer’s catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMS controller. Protection shall be provided for the individual communications and input/output terminations for each FMS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

F. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gage.
2. Other analog inputs shall be a minimum of number 22 gage, twisted, shielded.
3. Binary control function wiring shall be a minimum of number 18 gage.
4. Analog output control functions shall be a minimum of number 22 gage, twisted, shielded.
5. Binary input wiring shall be a minimum of number 22 gage.
6. Thermistors shall be equipped with the manufacturer's calibrated lead wiring.
7. 120V control wiring shall be #14 THHN in 3/4" conduit. Provide 4 or 20 percent fill extra wire in each conduit.

G. Splices

1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

H. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

2.06 CONTROL TRANSFORMERS

A. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be fused on both primary and secondary taps. Fusing shall not exceed 80 percent of the rated transformer output. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA must be external fused. Control transformers over 100 VA supplying power to a control panel shall be located

external to the control panel.

2.07 EQUIPMENT CONNECTIONS

A. Not Applicable.

2.08 HVAC SYSTEM TIMECLOCK

A. Timeclocks shall be 365-day astronomic type with the following features:
   1. Automatic input voltage selection from 120 to 277 VAC, 50/60 Hz.
   2. NEMA 1 Metal Enclosure
   3. Over 2,000 events plus holiday schedules.
   4. Advanced scheduling including relative dating, such as fourth.
   5. 30 A rated contacts.
   6. 100-hour supercapacitor eliminates the need for batteries.
   7. USB connection for uploading, downloading and transferring programs.
   8. Easy-to-follow on-screen menus for programming to-the-minute accuracy
   9. Non-volatile memory protects programming indefinitely
   10. Firmware upgradable in-field via USB or Ethernet
   11. Internally expandable, in 4-circuit increments, up to 16-circuits for 4, 8, and 12-circuit models
   12. PC App for easy scheduling or control, either remotely or through USB flash drive

B. Timeclocks shall be Intermatic Model ET90215C or equivalent.

2.09 CONTROL PANELS

A. Control panels shall be provided as required for mounting of system control devices as indicated on the Drawings. Panel shall be sized as required to accommodate controls with hinged door, key lock. Panel shall be constructed of metal with metal mounting backplanes. All panels shall be supplied with the same key. All panels shall be NEMA rated and UL listed. Hoffman or equivalent.

PART 3 EXECUTION

3.01 GENERAL

A. All devices, conduit, wiring, etc., shall be installed in a neat professional manner by skilled persons.

1. The installation of all aspects of the system shall comply with all applicable codes and regulations and with Division 26 Specifications.
2. The installation of all materials shall be in accordance with the published manufacturer's recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise the Engineer of the situation.
3. Where miscellaneous materials are required to complete an installation, i.e., isolation valves for pressure switches, wall switches for an exhaust fan control circuit, etc.; the materials shall be supplied as defined in the relevant Section of these Specifications. For example, Section 23 0523 specifies valve requirements, and Division 26 specifies electrical products and requirements.
4. Coordinate with other trades where installation of a particular component requires other trades to be involved. Installation coordination includes location the correct placement of thermowells, flow switches, dampers, control valves, control power circuits, etc. Care must be exercised to identify locations that meet the requirements of the manufacturer including upstream and downstream distances, pressures, temperatures, etc.

3.02 ROOM THERMOSTAT AND OCCUPANT CONTROLS

A. Wall mount thermostats shall be installed 44" A.F.F. to the center of the thermostat unless otherwise noted on the architectural drawings or specifications.

B. Provide locking thermostat cover for thermostats located in common areas and hallways.

3.03 CONTROL RELAYS

A. Control relays shall be field or panel mounted as indicated on the Drawings. If a relay is field mounted it will be installed in a NEMA I housing.

B. Control relays shall be installed in bases and the based mounted on a DIN rail. All accessories including end clips, jumpers, etc., shall be provided. All wiring shall be labeled. Multiple conductors shall be bundled and run by classification in plastic wireways. Relays shall be labeled as indicated in the shop drawings for ease in troubleshooting.

3.04 SMOKE AND FIRE DETECTORS

A. Smoke detectors and the associated wiring shall be installed in accordance with Section 23 0549.

3.05 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Comply with all Division 26 installation requirements.

B. Install low voltage power in conduit in the following locations regardless of local building code allowances otherwise.

1. Mechanical rooms.
2. Electrical rooms.
3. Vertical risers. (Exception: fire rated continuous closet like a telephone closet.)
4. Open areas where the wiring will be exposed to view or tampering.
5. Hard ceilings and walls.

C. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.

D. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

E. All wire-to-device connections shall be made at terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

F. Plug or cap all unused conduit openings and stubups. Do not use caulking compound.

G. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.

H. Set conduits as follows:
   1. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
   2. Oakum and lead, sealed watertight penetration through outside foundation walls.

I. Cap open ends of conduits until conductors are installed.

J. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18" and maximum length of 36" shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.

K. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.

L. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

3.07 CONTROL TRANSFORMERS

A. Control transformers shall be field mounted using a plate to mount on the associated junction box or panel using a foot-style mounting. Locations shall be as identified on the Drawings or as determined by field requirements. A phenolic label on each transformer shall identify the power source by breaker panel and circuit. Fusing of the primary and secondary sides and sizing shall be as defined by the NEC. Provide means of local disconnect for transformer to allow removal.

3.08 EQUIPMENT CONNECTIONS

A. Class II field wiring for all non-control device applications shall be installed under this Section of the Specification. This includes equipment such as VFDs, chillers, boilers, packaged air handling equipment, etc.

3.09 HVAC SYSTEM TIMECLOCK

A. Locate timeclock inside the building shown on the drawings or coordinate with the owner. Wire timeclock to associated mechanical equipment as outlined on the drawings.

B. Program the timeclock based on the occupancy schedule for the building as coordinate with the building owner.

3.10 TEMPERATURE CONTROL PANELS

A. All wiring shall be clearly labeled with Brady-type marker labels and run to numbered terminal strips or tubing manifolds these wire, tube, and terminal numbers shall be shown on all control diagrams. Wires and tubes shall be labeled at all connection points.

B. All control devices shall be labeled with engraved phenolic tags showing device number and name, model number, setpoint, range, action, etc. Panel Face indicators shall be labeled with engraved phenolic tags identifying what is shown on indicator.

C. Electronic digital indicators shall be provided where shown on the Drawings. Indicators shall be LED or LCD loop powered type and fully compatible with the associated transmitter and matched to the range of the transmitters. Indicators shall be flush mounted on the control panel door.

D. Terminal strips shall be provided in all control panels for the termination of all field wiring. An additional 25% but not more than 50 terminal strips shall be provided for future use. Terminal strips shall be rated for no less than 300 VAC, 1/4" in width, track mounted, and a slot provided for labeling strips. All terminals shall be labeled as shown on the as-built drawing. No more than two conductors shall be terminated on a single terminal.

E. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be provided with a phenolic label identifying the source of power.

F. Control panel front mounted pilot lights shall be provided where shown on the Drawings or electrical ladder diagrams. Lights shall have replaceable bulbs and lenses and shall incorporate a "push-to-test" feature. Voltage rating of pilot light may be full load voltage or dropped across a line resistor. In no case may the voltage to pilot lights exceed 120 VAC.

G. Control panels shall have wire ways installed to group all wiring within a panel. Panels shall be manufactured in a professional manner to the satisfaction on the Owner and Engineer.

END OF SECTION

SECTION 23 2313 - REFRIGERANT PIPING SYSTEM AND EQUIPMENT

PART 1 GENERAL

1.01 REQUIREMENTS

A. Conform to the applicable provisions of the General Conditions, the Supplemental General Conditions and the General Requirements.

1.02 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.
B. Section 23 0504, Pipe and Pipe Fittings.
C. Section 23 0505, Piping Specialties.
D. Section 23 0523, Valves.
E. Section 23 0700, HVAC Insulation.
F. Division 26, Electrical.

1.03 QUALIFICATION PROCEDURES

A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements. In no situation shall any refrigerant be discharged to the atmosphere.

PART 2 PRODUCTS

2.01 SPLIT SYSTEM HEAT PUMPS AND AIR COOLED CONDENSERS

A. Units shall be as specified on the Equipment Schedule on the drawings and Section 23 3000.

2.02 PIPING

A. Refrigerant piping materials and installation shall be in accordance with the best working and piping practices for Freon refrigerants. The Contractor shall install the refrigerant piping using Type "L" hard drawn copper tubing, Federal Specification WW-T-749, with silver solder joint. All piping shall be installed in a straight manner, free from traps, and shall be provided with

plugged or capped ends, as it is erected, to prevent dirt from entering. The piping system shall be provided with gauges as required for the operation of the system. The piping is shown schematically on the drawings, verify exact arrangement and pipe sizing with equipment manufacturer.

2.03 VALVES

A. Expansion valves shall be of the thermostatic type as manufactured by Alco, Sporlan, or equivalent, and shall be gas charged with capillary tube, external superheat adjustment and external equalizing connection. The expansion valves at each apparatus shall be protected by a strainer in the refrigerant liquid line to that group. The strainer shall be as manufactured by the Henry Valve Company, or equivalent, not less than line size and provided with shut-off valves before and after, and furnished with the packaged reciprocating unit.

B. Solenoid valves shall be suitable for the system in which they are used and shall be designed specifically for use with Freon refrigerants. Solenoid valves shall be furnished with the packaged reciprocating unit.

C. Refrigerant line valves shall be packless type or packed type with gas tight cap seal with wheel, globe, angle, or "T" needle type, with hard metal seats and shoulders on stems to permit packing stuffing boxes while open under pressure, or sealed diaphragm type.

2.04 DRYER

A. In each liquid line, install a suitable silica gel filter and dryer. Dryer shall be furnished with the chiller.

PART 3 EXECUTION

3.01 INSTALLATION

A. Piping installation shall conform to the requirements of Section 23 0500, Common Requirements for HVAC, Section 23 0504, Pipe and Pipe Fittings and the manufacturer’s specific requirements and instructions.

3.02 TESTING OF REFRIGERANT PIPING SYSTEM

A. After the installation of the refrigerant piping system has been completed, all piping shall be tested and proven tight for a period of twenty four (24) hours at a pressure of 150 lbs. per square inch using dry nitrogen.

3.03 EVACUATION AND CHARGING

A. Upon completion of the piping pressure test, the refrigerant circuit shall be evacuated to 500 microns using a closed tube manometer and a high vacuum pump (using an electronic vacuum gauge that reads in microns) to ensure tightness of the piping and to remove air and moisture from the piping system. Upon completion of evacuation and acceptance of the system tightness, the vacuum shall be broken by the introduction of the refrigerant.

3.04 REFRIGERANT AND LUBRICATING OIL

A. Contractor shall furnish and install all of the refrigerant required to develop the system to its full rating, and in addition to the initial charge, the Contractor shall be required to provide all refrigerant required for the proper operation of the refrigeration apparatus during the first season's operation. Contractor shall guarantee that the loss of refrigerant for a season's operation shall not exceed 10% of the full charge of the system and he shall furnish any refrigerant required above this amount. This guarantee shall remain in effect until such time as the Contractor shall demonstrate this performance for one full year's operation. The Contractor shall be required to provide the initial charge of lubricating oil for all refrigeration apparatus and related equipment, and shall furnish a chart listing the type of oil and a schedule for maintenance that should be used with the various equipment.

3.05 PRESSURE RELIEF DEVICES

A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15-1994. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.

B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

END OF SECTION

SECTION 23 3000 - AIR TEMPERING SYSTEM AND EQUIPMENT

PART 1 GENERAL

1.01 REQUIREMENTS

A. Provide all products, labor and services necessary to construct and demonstrate proper functionality of the HVAC and exhaust systems indicated on the drawings and specified herein.

B. Conform with applicable provisions of the General Conditions, the Supplemental General Conditions and General Requirements.

C. See Sections 23 0500, 23 0548, 23 0549, 23 0593, 23 0700, and 23 0900 for additional requirements.

D. Comply with the Equipment General Requirements in Spec Section 23 0500.

1.02 SCOPE

A. Install control dampers supplied under Section 23 0900. Adjust dampers for smooth operation.

1.03 SUBMITTALS

A. Submit the following for review and approval:

1. All equipment shown on the equipment schedule and elsewhere on the drawings. Submit evidence or certification that equipment complies with ASHRAE Std. 90.1.
2. Ductwork construction standards, sheet metal, plenums, ductwork accessories, etc.
3. Flues and vents: Materials of construction and accessories. For vents with horizontal offsets or expansion joints, submit layout for review.
4. Dampers for fire and smoke control: For each type of damper proposed, submit manufacturer's literature demonstrating compliance with all aspects of the specifications and drawings. Submit manufacturer's installation instructions.
5. Air Filters and Filter Gauges
6. Grilles, Registers & Diffusers: Configuration, materials of construction, finish, mounting details, and performance data including throw, static-pressure drop, and noise ratings. Submit for type only, but supplier shall check and verify that the indicated diffuser type and sizing are appropriate for each area. Advise of any concerns in any areas.

1.04 QUALITY ASSURANCE

A. Comply with the following codes & standards:
   1. UMC 2006 Chapter 6 – Duct Systems
   2. UMC 2006 Standard 6-2, Standard for Metal Ducts
   3. SMACNA 2005 HVAC Duct Construction Standards – Metal and Flexible, including Addendums
   4. SMACNA Round Industrial Duct Construction Standards – 1999
   5. SMACNA Rectangular Industrial Duct Construction Standards – 2004
   6. NFPA-90A-2002 - Standard for the Installation of Air-Conditioning and Ventilating Systems

B. Component Characteristics
   1. All components within ducts and plenums shall be non-combustible or shall have a flame spread less than 25 and smoke developed less than 50 when tested as a composite product per NFPA 255, ASTM E84, or UL 723, except where specifically permitted by the UMC and noted in the drawings or specs.

1.05 DIMENSIONS

A. Compare all drawings and verify all dimensions both on the drawings and in the field before laying-out, cutting, and fabricating the work.

B. Refer to Section 23 0500, Common Work Requirements for HVAC, for coordination drawing requirements.

PART 2 PRODUCTS

2.01 DUCTWORK AND PLENUMS

A. Materials: Construct all ducts, casings, plenums etc. from galvanized steel sheets except as indicated. Sheets shall be free of blisters, slivers, pits, and imperfectly galvanized spots. Reinforcing angles and bars, and duct support materials shall be same material as ductwork if exposed to the air stream, or galvanized steel if not exposed to the air stream.
   1. Galvanized Steel: Per ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) by the Hot Dip Process G90 coating designation.

B. Flexible Ducts: Factory fabricated, listed as a Class 1 Air Duct per UL 181 with aluminum foil interior liner, corrosion resistant helix mechanically locked to fabric to ensure dimensional stability, helix separated from air stream, R-6 fiberglass insulation, and metalized outer vapor barrier. Ducts shall be rated at 10-inch positive pressure, 5-inch negative pressure, 0.1 perm per ASTM E96, and -20 to +250°F. Flexmaster Type 3M, Thermaflex M-KC, OAE.

C. Ductwork Accessories

1. Sealers: Water based, for use on galvanized steel and with the other materials specified herein, suitable for use at -20 to +200°F and duct pressures to 10 inches wg, dry to the touch within 12 hours, sufficiently flexible to pass a 0.25-inch mandrel test, listed per UL-181A & 181B, and suitable for storage and application at 40–110°F. Approved Manufacturers: Carlisle Coatings & Waterproofing "Hardcast," Foster, RCD, AM Conservation Group, OAE.
2. Tapes: 4" woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal. Water, mold, and mildew resistant for indoor and outdoor service. Sealant shall be modified styrene acrylic.

2.02 SHEET METAL ACCESSORIES

A. Dampers: Factory fabricated, suitable for use with air at -20 to +240°F, galvanized steel housing and blades except as noted, rated for indicated pressures in either direction and performance rated per AMCA-500.

1. Shafts: Square or hexagonal steel, 3/8-inch or 1/2-inch, continuous through damper, mechanically fastened to damper blade, and extending through frame as required for actuator or standoff bracket and locking quadrant as required by table below.
2. Bearings: Provide for each side of each shaft, molded synthetic or stainless steel sleeve type.
3. Multi-blade dampers: Except as indicated, provide parallel-blade for 2-position applications and opposed blade for modulating applications. Provide jackshafts as required to drive large dampers.
4. The dampers described in this section are assigned Type Numbers D1 through D23. The following table summarizes key characteristics of each type of damper. Drawings and Part 3 – Execution, indicate which type of damper to use in each application.

Type	Shape	Blade	Max Size (inches)	Multiple Sections	Rated Velocity (FPM)	Rated Shutoff Press. (in. wg)	Seals	Leakage (CFM/SF @ 1 in. DP)	Notes	Ruskin Model
D6	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2	2	CD50

Note 1: Provide locking hand quadrant and 2-inch standoff bracket

Note 2: Aluminum Construction

B. Flexible Connectors: Except as noted flexible connectors shall be heavy fiberglass cloth; coated to be air tight, water tight, fire retardant; suitable for temperatures of -20 to +200° F; rated for 10 in. wg positive or negative; with tensile strength minimum 450 lb/inch in the warp and 340 lb/inch in the filling. Provide flexible connectors in 3-3-3 configuration, with 3-inch galvanized steel strip along each edge and 3-inches of flexible fabric in the center.

1. Standard Applications: Flame spread 20, smoke developed 40, Ventfabrics Ventglas OAE
2. Applications Exposed to Sun and Weather: Double coated with du Pont Hyphalon, Ventfabrics Ventlon OAE.
3. Applications from 200 – 500° F: Tensile Strength 285 lb/inch in the wrap and 185 lb/inch in the filling. Ventfabrics Ventsil OAE
4. Corrosive Applications: Teflon coated, Ventfabrics Ventel OAE.

C. Duct and Plenum Access Doors: Galvanized steel, gasketed. Size as required to properly inspect and service components located within the ductwork. Ruskin, Acudoor, Ductmate, OAE.

1. Rectangular ducts up to 2-inch positive or negative SP: Minimum 22 gauge frame and door thru 12-inch size, 20 gauge door for larger sizes, double gasketed (between door and frame, and between frame and duct) with cam locks, either hinged or removable. Ruskin ADH22, ADC22, ADHW22, or ADCW22, Ventfabrics, OAE
2. Round or Rectangular Ducts to 12-inch Positive Pressure: Removable oval sandwich style with gasketed inner door, insulated outer door, and large hand knobs. Ruskin ADR and ADF.
3. Ducts to 12-inch Negative Pressure: Ruskin ADHP-3.
4. Plenum Access Doors: Factory fabricated frame and door rated to 4-inch positive or 8-inch negative pressure. Provide mill finish and neoprene seals to limit leakage to less

than 0.1 CFM/inch perimeter with door closed. Doors shall open against air pressure.

a. Frame: Extruded aluminum with 1.5-inch flange and mitered corners

b. Door: Extruded aluminum mitered frame, double wall 24-gauge galvanized steel panel with minimum R-5 insulation isolated from the air stream, full-length piano hinge and two heavy-duty latches similar to Ventlok 310.

c. Approved Manufacturers: Ruskin GPAD or approved equal.

D. Turning Vanes:

1. Single wall: Per SMACNA HVAC Duct Construction Standards Figure 2-3 & 2-4.

2. Double wall: Airfoil shape with smoothly rounded entry nose and extended trailing edge, minimum 2" x 3" vane crossection, hot dipped galvanized steel, 26-gauge vanes, 24-gauge runner, each vane double pinned to each runner, field adjustable to required elbow aspect ratio. Performance shall not exceed the following for a 24 x 24 elbow at 2000 FPM average: Air pressure drop 0.105 in. wg; aound generated 54 dB re 10^-12 watts. Aero/Dyne Co. Model HEP, Airsan, Elgen, or equivalent.

E. Thermometers: As specified in Section 23 0505.

F. Barometric Pressure Balance Dampers: Air Balance, Inc. units with adjustable counter weight, aluminum air foil design blades, nylon bearings. Match frame assembly to wall or duct.

2.03 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

A. General: Factory-built metallic vent system, UL Listed components. Each component shall bear indication of its UL listing.

1. Heat Resistant Paint: Glidden, Metallite OAE.

2. Approved Vent Manufacturers: Metal Fab, Metalbestos, Schebler, Ampco, OAE.

B. Type B Vent: Listed per UL 441 for use with UL Listed Category I (gas or propane fired, negative pressure, non-condensing) appliances to 530^{o} F, round or flat oval as indicated, double wall with aluminum alloy inner wall, galvanized steel outer wall, both walls hemmed to eliminate sharp edges, minimum 1/4-inch air space for sizes 6-inches and smaller and minimum 1/2-inch air space for sizes 7-inches and larger, with guides to maintain air space. Provide UL Listed vent cap. Metal Fab Type M.

1. Barometric Draft Regulator: UL Listed, double acting type.

C. Type III Vent: For use with Category III appliances or other positive pressure, non-condensing appliances including oil-fired or solid-fuel equipment not exceeding 1200^{o} F exhaust

temperature. Listed per UL-103 for use with gas, liquid or solid fuels per NFPA-211 which produce gases up to 1400° F continuously and 1800°F intermittently. Double wall with spacers to maintain alignment, rated for 10-inch clearance to combustibles, 4-inch clearance to noncombustible, and zero clearance to fire-rated or non-combustible chase.

1. Inner Pipe: Connected with V-bands of same material as inner pipe, and sealed with silicone sealant appropriate for the exhaust gas temperature. Pressure tight to 60 inches water.
2. Outer Pipe: Seal with V-band of same material as outer pipe. Provide silicone sealant for portions exposed outdoors.
3. Expansion Joints: Bellows type.
4. Options and Accessories:
    a. Inner Wall: 304 SS.
    b. Outer Wall: Aluminized steel
    c. 12-year warranty against defects in materials and workmanship
    d. Uninsulated with minimum 1-inch space between inner and outer walls. Metal Fab Type PIC.

2.04 GRILLES, REGISTERS AND DIFFUSERS

A. General: Performance rated per ASHRAE Std 70, *Method of Testing for Rating the Performance of Air Outlets and Inlets*, steel with baked white enamel finish except as noted, for installation on a fixed surface or a lay-in T-bar ceiling as indicated on architectural drawings, rigidly constructed, vibration free, with inlet collar of sufficient length to connect inlet ductwork, sized as shown on drawings. Where frames are provided for installation in fixed surfaces, frames shall be approximately 1-1/8” wide. Sound performance rated per ADC and based on room absorption of 10dBre10^{-12} Watts and one diffuser.

1. Approved Manufacturers: Price, Krueger, Titus, Anemostat, OAE

B. Types as follows. See also the Grille and Diffuser Schedule on drawings.

1. Sidewall Return, Exhaust and Transfer Grilles: Fixed horizontal bars on 3/4" centers set at 30-45 degrees, surface mounting frame. Price 530.

2.05 FANS

A. Centrifugal Wall Exhuast: Provide as scheduled on drawings UL 705 listed, direct drive up-blast centrifugal blower for exterior wall mounting. Provide wall braket for sidewall mounting, backdraft damper, backward inclined centrifugal wheel, spun aluminum inlet shroud, bird screen, disconnect and variable speed controller.

Units shall be Greenheck Model CUE, OAE

B. Ceiling Exhaust Fan: Direct driven centrifugal blower type, ceiling mounted, with backdraft damper, outlet duct collar, galvanized housing with integral plastic grille, and customizable speeds capable of exhausting the capacities scheduled on drawings.

Units shall be Greenheck Model SP, OAE

C. In-line centrifugal supply fans: Provide as scheduled on drawings, UL 705 listed belt-driven, horizontally suspended from structure with rubber-in-shear vibration isolators, hinged housing to service wheel, belt, drive, motor, with spun venturi throat, backward inclined centrifugal wheel, and AMCA certified. Provide with NEMA premium efficiency motor, disconnect switch, and L10 life, 100,000 hour pillow block bearings with grease fittings.

Units shall be Greenheck Model BSQ or OAE.

D. Propeller exhaust fans: Provide as scheduled on drawings, panel frame design, direct drive, AMCA rated, cast aluminum propeller, with protective wire fan-motor-belt guard that completely protects hands from moving parts. Motor shall be premium efficiency, totally enclosed, and accessible from within building. Furnish barometric dampers to open whenever the exhaust fan operates and 45°weatherhood with birdscreen.

Units shall be Greenheck Model AER or OAE.

2.06 HIGH VOLUME LOW SPEED (HVLS) FANS

A. General: Provide as scheduled direct drive overhead fan. Fan performance shall be AMCA certified and UL 507 listed.

B. Construction: Fan construction shall include a universal ceiling mount and heavy-duty

mounting kit that is coordinated by the contractor for this specific project mounting requirements, height, and drops. Universal ceiling mount shall be constructed of heavy-gauge steel and shall include a bidirectional pivot to accommodate any ceiling angle. Fans shall also include a heavy-gauge steel downtube to provide a structural connection between the universal ceiling mount and fan motor. Downtube shall include a factory-programmed variable frequency drive. Downtube shall also include a welded guy wire connection ring for fast and secure connection of the fan's guy wires. Fan shall be provided with a multipoint, redundant safety system comprised of a heavy-duty safety retention cable, guy wire kit, hub retention system, and airfoil retaining ring as standard.

C. Motors/Fans: Shall be of the high torque, low-speed direct drive type, and include plug-and-play connectors for power and control wiring to the variable frequency drive. Motors shall also be provided with a factory-installed hub. Airfoils shall be constructed of extruded aluminum and provided with a mill finish. Airfoils shall also be provided with winglets. Fan shall be provided with a multipoint, redundant safety system comprised of a heavy-duty safety retention cable, guy wire kit, hub retention system, and airfoil retaining ring as standard.

D. Options: Include disconnect, fire protection interlock to stop fans when system is activated and factory keypad control systems capable of controlling of controlling fans as indicated on the control drawings.

E. Manufacturer: Units shall be Greenheck DS-3 OAE.

2.07 SPLIT SYSTEM HEAT PUMP UNITS

A. General: Provide as scheduled on the drawings, wall mounted cooling/heating units: furnish and install self-contained factory assembled evaporator units where shown on the drawings. Units shall be supplied complete with supply and return air grilles, permanent or throwaway filters, and access panels to service all interior components. Cabinet shall be insulated.

B. Evaporator: The evaporator unit shall include fan, evaporator coil, and thermal expansion valve. Fans shall be direct drive, forward curved centrifugal type, and dynamically balanced. Motor shall be provided with internal overload protection. Coil shall be seamless copper with aluminum fins tested to 460 psig. Controls shall be packaged with low voltage connection for a factory provided remote mount temperature sensor. Provide all necessary transformers and relays for packaged operation.

C. Condenser: Condenser unit shall provide cooling and heating for evaporator unit, and shall be manufactured by the same company as evaporator unit. Unit shall be completely pre-piped and wired at the factory. Compressor shall be hermetic rotary or reciprocating type with resilient mountings. Include crankcase heaters, filter, dryer, site glass, overloads, and manual high pressure re set switch. Unit shall be capable of operation down to 0 degrees F outdoor ambient temperature. The condenser fan shall be direct driven propeller type with fan guards arranged for horizontal discharge. Coils shall be copper tubes with aluminum fins. Controls shall be packaged with low voltage connections for the evaporator unit. Provide all necessary transformers and relays for packaged operation.

D. Options: Provide with low voltage unit mounted controls, and condensate pump package. Manufacturer's representative shall visit project site to observe start-up of units, review installation and submit a report certifying proper installation and operation.

E. Units shall be Mitsubishi Model PKA/PUZ OAE.

2.08 ELECTRIC UNIT HEATERS

A. Suspended Electric Unit Heaters: Provide as scheduled on the drawings suspended electric unit heaters: Axial flow propeller fan type, horizontal arrangement, adjustable discharge louver diffuser, nickel chromium alloy heating elements, manual reset, factory installed and wired contactors/starters and control circuits, motor and control circuits subdivided and fused in accordance with National Electric Code, UL Listed. Furnish with unit mounted thermostat, power disconnect switch, wall mounting bracket, and safety fan guard. Markel 5100 Series, or equivalent.

B. Recessed Wall Electric Unit Heaters: Provide as scheduled on the drawings packaged electric wall recessed unit heaters: Axial flow propeller fan type, horizontal arrangement, heavy duty 16 ga steel grille with aluminum frame, nickel chromium alloy heating elements, manual reset, factory installed and wired contactors/starters and control circuits, motor and control circuits subdivided and fused in accordance with National Electric Code, UL Listed. Furnish with unit mounted thermostat, power disconnect switch rough-in box, surface mounting frame and 2” semi recess extender if necessary. Markel 3320 Series, or equivalent.

2.09 GAS FIRED UNIT HEATERS

A. Provide 82% minimum efficiency gas fired power vented unit heaters as scheduled on drawings. Units shall be natural gas fired, DWDI forward curved belt driven fan type, AGA approved. Furnish complete with all required safety and operating controls including; low voltage transformer relay, fan time delay relay, high limit switch, fan controls, automatic 24 volt gas valve, solid state ignition, pressure regulator, main gas cock, control transformer, 24 volt low voltage non-programmable thermostat suspended from unit and summer fan switch. Totally enclosed motor with thermal overload protection, aluminized steel burners and heat exchangers, integral draft diverter, safety fan guard, adjustable discharge louvers and 30° downward hood.

B. Units shall be Modine model BDP or equivalent.

PART 3 EXECUTION

3.01 DUCTWORK AND PLENUMS

A. Ductwork

1. Construct ductwork with wall thicknesses and reinforcing per the SMACNA HVAC Duct Construction Standards, Second Edition, 1995, and UMC 2006 Chapter 6, Pressure Classes: Construct ductwork to the following pressure classes:

Duct Element Description	Relative Pressure	Pressure Class
From Outside Air Louver to Filter	N	1”
From Air Handling Unit to Terminal Unit	P	4”
From Single Zone AHU to Diffuser	P	2”
From Return Grille to Fan	P	1”
From Return Grille to Fan	N	1”
From Return Fan to Relief Louver	P	1”
From Exhaust Register to Exhaust Fan	N	2

2. Minimum thickness for sheet metal ductwork: 26 gauge.

3. Sealing: Seal ductwork and plenums as follows:

	Seal Class			
	Supply Ducts			
Location	<2 in wg	>2 in wg	Exhaust	Return
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces including RA Plenums	C	B	B	A

Seal Class	Description
A.	All transverse joint, longitudinal seams and duct wall penetrations.
B.	All transverse joints and longitudinal seams.
C.	Transverse joints.

a. Apply duct sealer to inside of seams and joints. Do not use pressure sensitive tape as the primary sealant.

4. Clearance to earth: Maintain minimum 4-inch separation between ductwork insulation and earth.

5. Openings in Ductwork: During installation protect the open ends of ducts to prevent debris and dirt from entering.

6. Provide turning vanes in square elbows of low velocity supply and exhaust ductwork.

7. Collars: Where exposed ducts pass through walls, floors, or ceilings, provide a tight-fitting, flanged sheetmetal collar around duct and tight against finished surface to cover opening and present a neat appearance. Lock collar to duct.

8. Cross Breaking: Cross-break low velocity rectangular sheetmetal ducts on all four sides. Cross break sheet metal between standing seams or reinforcing angles. The center of cross break shall be of the required height to assure surfaces being rigid. Do not cross-break high velocity plenum panels.

9. Grilles Registers and Diffusers: Install plumb, affix to general construction as appropriate, make air-tight connection to ductwork, and adjust air flow pattern to achieve appropriate velocities in the occupied zones. Request direction from Engineer if any question exists regarding proper air flow adjustment.

10. Duct Thermometers: Provide thermometers to indicate mixed air, outside air, and supply air of indoor air handling units over 2,500 cfm and where shown on the Drawings.

11. Test Holes: Provide test holes in ducts at locations where testing is required per Section 23 0593 and as requested by the T&B agent. Close test holes with rubber plugs. Reseal all insulated ductwork with the same insulation, jacket and vapor barrier material after T&B is complete.

12. Closure Systems:
    a. Rigid Air Ducts: Comply with UL 181A – Standard for Closure Systems for Use with Rigid Air Ducts and Air Connectors.
    b. Flexible Air Ducts: Comply with UL 181B – Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors.
13. Factory Made Air Ducts: Install in accordance with the terms of their listing and the manufacturer's recommendations.
14. Acoustic Insulation: See Section 23 0700, HVAC Insulation. Fabricate ductwork so the dimensions indicated on the drawings are the clear dimensions for air flow inside the acoustic insulation.
15. Coordination with Building Construction
    a. General: The drawings show the general intended configuration of the ductwork. Provide additional offsets where necessary to coordinate with the building construction or with the work of other disciplines. Transition ductwork as required at no change in contract price. Where this is necessary, submit for review and maintain the indicated flow areas.
    b. Ductwork is frequently routed through bar joists and between bar joists. Coordinate duct locations with joist submittals prior to fabrication.
16. Exterior Ductwork: Install ductwork as specified herein and insulate per Section 23 0700. Then enclose the exposed top and sides of ductwork with 28 gauge galvanized steel or 26-guage aluminum to protect the insulation. Repair any damage to the insulation jacket. Slope sheet metal enclosure to shed water.

B. Hangers and Supports
1. Securely support ducts per SMACNA and UMC Table 6-7. Provide support at each concentrated load and at each change in direction. Provide supports on each side of rectangular ducts and equipment. Where vertical ducts pass through floors or roofs, support with angles or other steel members attached to minimum two opposite sides of duct. Size supports to rigidly support the ductwork. Provide lateral support.
2. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
3. Horizontal Round Ducts: 30 inches and larger in diameter: Provide 2" x 2" x 1/8" black steel rolled angle ring on 6-ft centers, and support from angle.

C. Dampers: Install dampers with shafts horizontal. Locate dampers so that actuators are readily accessible. Verify that dampers operate smoothly.

1. Manual Dampers (Balancing Dampers): Damper Types D1 through D23 are all suitable for use as manual balancing dampers. Provide locking quadrants.
2. Automatic Applications: The following damper types may be used for automatic applications: D4, D5, D6, D7, D21, D22 and D23. Provide damper actuators per Section 23 0900.

D. Flexible Connectors: Provide flexible connectors at locations indicated on the drawings and at the inlet and outlet of each fan directly connected to duct system. Select flexible connectors appropriate for the application. Provide steel spring vibration isolators spanning across flexible connections of isolated fan housings to prevent blow-apart due to horizontal displacement of fan housings.

E. Access Doors: Provide as required for access to all components located within ductwork. Locate to facilitate access to such components. Size as appropriate. In addition to locations specifically called out on the drawings or elsewhere in these specs, provide access doors at the following: FDs, SMDs, FSDs, instrumentation mounted within ductwork, fan bearings.

F. Turning Vanes: Provide turning vanes in square elbows of all supply ducts. Single wall turning vanes may be used in ducts up to 1500 FPM and 24-inch vane length. Provide double wall turning vanes in ducts exceeding either of these criteria.

G. Louvers: Coordinate louver size and construction with structural and architectural openings to assure proper fit. Securely fasten louver to internal structural members to withstand a force of 25 lb/sf plus a safety factor of 3.0.

H. Instrumentation: Install duct thermometers and filter gauges so they are easily readable from the operator level.

3.02 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

A. General: Install per the drawings and these specifications, manufacturer's instructions, the terms of the vent's UL Listing, the UMC and NFPA-211.

1. Use the same type vent for the entire system from the equipment connection to the termination outside. Provide all fittings, transitions, adapters, supports, storm collars, etc.
2. Install per the venting requirements of the appliance manufacturer. Comply with clearances per UL Listing. Minimize offsets and resistance to flow. System shall

develop a positive flow adequate to remove products of combustion to outside. Do not run any portion of the vent system through any supply or return air duct or plenum. Do not connect the vent from any Category I or II (non-positive pressure) appliance with any Category III or IV (positive pressure) appliance. Do not install any manually operated damper at any point in vent system.

3. Properly support the system and make provisions for thermal expansion. Install so as to prevent leakage of flue gases into the building. Provide drain connections where condensate is likely to accumulate, and pipe to spill over floor drain.
4. Provide ventilated thimbles where vents pass through walls, floors and roof. Paint all galvanized or aluminized steel parts exposed to the weather with one coat of corrosion and heat-resistant primer, and one coat of heat resistant paint.
5. Terminate low heat appliances as indicated on the drawings, but not less than:
    a. 3 ft above the highest point where the vent passes the roof.
    b. 2 ft above any portion of a building within a horizontal distance of 10 ft.
    c. 3 ft above any forced air inlet located within 10 ft.

B. Type B: If a draft damper is supplied with the appliance for installation in the flue, install it per manufacturer's instructions. If appliance is listed for use with a draft hood but is not supplied with one, provide a properly sized barometric draft regulator immediately in the vent outlet, and install per manufacturer's recommendations. Pitch vent up minimum 1/4-inch per foot. Join sections per manufacturer's recommendations using sheet metal screws or proprietary closure system of a UL Listed venting system. Provide vent cap,

C. Type III and IV: Install per the drawings and these specifications, per manufacturer's instructions, per the terms of the vent's UL listing, and per NFPA-211.

3.03 GRILLES REGISTERS AND DIFFUSERS

A. Install grilles, registers & diffusers (GRDs) square with building construction. Mount sidewall GRDs minimum, 3-inches above floor level. If GRDs have provisions to adjust the direction of air flow, submit a written recommendation regarding the best direction for air flows, obtain written approval from the Owner's Representative, and adjust GRDs accordingly.

B. Verify frame types with architectural RCPs prior to ordering GRDs.

END OF SECTION

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General Conditions, Supplemental General Conditions, and Division 1 Specification Sections apply to all Sections of Division 26.

B. The requirements listed under General Conditions and Supplementary Conditions and the General Requirements are applicable to this section and all subsequent sections of Division 26 and form a part of the contract.

C. Division 1, Coordination for additional requirements.

D. Division 1, Cutting and Patching, for additional requirements.

E. Division 1, Submittals, for additional requirements.

F. Division 7, Firestopping, for additional requirements.

G. Division 7, Joint Sealants, for additional requirements.

H. Division 9, Painting, for additional requirements.

I. Division 31, Site Work for Trenching, Backfilling and Compaction requirements.

1.02 SUMMARY

A. This Section includes general administrative and procedural requirements of electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals
2. Coordination Drawings
3. Record Documents
4. Maintenance Manuals
5. Rough-Ins
6. Electrical Installations
7. Cutting and Patching

1.03 ELECTRICAL DIVISION INDEX

Section 26 0500 Common Work Results for Electrical

Section 26 0519	Low-Voltage Electrical Power Conductors and Cables
Section 26 0526	Grounding and Bonding for Electrical Systems
Section 26 0529	Hangers and Supports for Electrical Systems
Section 26 0533	Raceways and Boxes for Electrical Systems
Section 26 0543	Underground Ducts and Raceways for Electrical Systems
Section 26 0544	Sleeves and Sleeve Seals for Electrical Raceways and Cabling
Section 26 0550	Installation Coordination
Section 26 0553	Identification for Electrical Systems
Section 26 0572	Overcurrent Protective Device Short-Circuit Study
Section 26 0573	Overcurrent Protective Device Coordination Study
Section 26 0574	Overcurrent Protective Device Arc-Flash Study
Section 26 0800	Electrical Facility Startup/Commissioning
Section 26 0880	Electrical Acceptance Testing
Section 26 0913	Lighting Control Equipment
Section 26 0923	Digital Occupancy & Daylight Management Control System
Section 26 2213	Low-Voltage Distribution Transformers
Section 26 2413	Switchboards
Section 26 2416	Panelboards
Section 26 2726	Wiring Devices
Section 26 2813	Fuses
Section 26 2816	Enclosed Switches and Circuit Breakers
Section 26 2820	Ground-Fault Protection
Section 26 3213	Diesel Engine Generators
Section 26 3353	Static Uniterruptable Power Supply
Section 26 3623	Automatic Transfer Switches
Section 26 4112	Lightning Protection for Structures
Section 26 4313	Surge Protection for Low-Voltage Electrical Power Circuits
Section 26 5119	LED Interior Lighting
Section 26 5219	Emergency and Exit Lighting
Section 26 5619	LED Exterior Lighting

1.04 CODES AND PERMITS

A. Perform electrical work in strict accordance with the applicable provisions of the National Electrical Code, Latest Adopted Edition; National Electric Safety Code, Latest Edition; International Building Code, Latest Adopted Edition as interpreted by the State of New Mexico, City of Santa Fe, and the National Fire Protection Association (NFPA Regulations), as referenced by adopted codes. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

B. Secure and pay for all permits necessary for performance of the work. Pay for all utility connections unless otherwise specified herein.

C. The following lists applicable codes and standards that, as a minimum, shall be followed. All of the latest adopted by the State of New Mexico

Applicable county and state electrical codes, laws and ordinances.
National Electrical Manufacturer's Association Standards
National Electrical Code
National Electrical Safety Code
Underwriters Laboratories, Inc. Standards
American National Standards Institute
American Society for Testing Materials Standards
Standards and requirements of local utility companies
National Fire Protection Association Standards
Institute of Electrical and Electronics Engineers Standards
Insulated Cable Engineers Association
Occupational Safety and Health Act
Uniform Fire Code
Americans with Disabilities Act
Commercial and Industrial Insulation Standards (MICA)
New Mexico Night Sky Protection Act.

1.05 RECORD DRAWINGS

A. Maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all electrical work, and in particular, where changes were made during construction. Use red color to indicate additions or corrections to prints, green color to indicate deletions, and yellow color to indicate items were installed as shown. Keep record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect and Owner's Representative during the construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set. Transmit drawings to the Architect and Owner's Representative at the conclusion of the project for delivery to the Owner's Representative.

B. Prepare record documents in accordance with the requirements in Division 1, Section 01 77000 - PROJECT CLOSEOUT. In addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.06 QUALIFICATIONS

A. All electricians shall be skilled in their respective trade.

1.07 SUBSTITUTIONS

A. Identification of Division 26 equipment, luminaires, and materials listed within this Specification and in the Equipment Schedules on the drawings, which are identified by manufacturer's name, trade name, and/or model numbers are generally not meant to give preference to any manufacturer, but are provided to establish the design requirements and standards.

B. Equipment submitted for substitution must fit the space conditions leaving adequate room for maintenance around all equipment. A minimum of 36 inches, or more if required by Code, must be maintained clear in front of all electrical panels, starters, gutters, or other electrical apparatus. Submit drawings showing the layout, size and exact method of interconnection of conduit, wiring and controls, which shall conform to the manufacturer's recommendations and these specifications. The scale of these drawings shall be scale of Contract Drawings. The Contractor shall bear the excess costs, by any and all crafts, of fitting the equipment into the space and the system designated. Where additional labor or material is required to permit equipment submitted for substitution to function in an approved manner, this shall be furnished and installed by the Contractor without additional cost to the Owner.

C. Equipment submitted for substitution shall be approved in writing by the Owner or his representative and shall be accompanied by the following:

1. A sample of each item submitted for substitution shall accompany the submittal.
2. Provide a unit price quotation with each item intended for substitution. Include a unit price for the specified item and a unit price for the intended substitute item. Provide a total (per item) of the differential payback to the Owner should the intended substitute item be approved as equivalent to that which is specified.
3. Reimburse the Owner for the Architect/Engineer's additional services required to review and process substitutions.

1.08 PRIOR APPROVAL

A. No prior approval. Substitutions as required by division 01

B. Refer to Division 01 for additional information.

1.09 HAZARDOUS CONDITIONS

A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.10 DEFINITIONS

A. Definitions of terms will be found in the National Electrical Code.

B. Whenever a term is used in this Specification which is defined in the Code, the definition given will govern its meaning in this Specification.

C. Whenever a technical term is used which does not appear in the Code, the definition to govern its meaning in these Specifications will be found in the Standard Dictionary of Electrical and Electronic Terms, published by the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.

D. "Provide" means furnish, install, connect and test unless otherwise noted.

1.11 SUBMITTALS

A. The Contractor shall submit submittal brochures of equipment, luminaires and materials to be furnished under Division 26. The submittal will be clearly identified with the model number and parts that make up the specified product.

B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.

C. Install equipment in accordance with the manufacturer's recommendations. Provide accessories and components for optimum operation as recommended by the manufacturer.

D. Costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.

E. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification from the Architect/Engineer that submittals have been reviewed and marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED." Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter to the Architect/Engineer. In no way is a review and comment by Architect/Engineer an approval of submitted products. It is the Contractor’s responsibility to ensure submittals are in accordance with the design and specifications.

F. Review of Submittals: Submittals will be reviewed with reasonable promptness, but only for conformance with the design concept of the Project and for conformance with the information indicated on the Drawings and stated in the Specifications. Review of a separate item as such will not indicate review of the assembly in which the item functions. Review of submittals shall

not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work. Review shall not relieve the Contractor of responsibility for the equipment fitting within the allotted space shown on the drawings with all clearances required for equipment operation, service and maintenance including a minimum of 3 feet clear in front of all electrical equipment and panels as defined by the National Electrical Code. Any relocation of mechanical and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.

G. Shop Drawings: Unless the following information is included, shop drawings will be returned unchecked:

1. Cover sheet for each submittal, listing equipment, products, and materials, and referencing data and sections in Specifications and drawings. Clearly reference project name and provide space for a review stamp.
2. Cover sheet shall clearly identify deviations from specifications, and justification.
3. Include all related equipment in a single submittal to allow complete review. Similar equipment may be submitted under a common cover sheet.
4. Size, dimensions, and weight of equipment.
5. Equipment performance under specified conditions, not a copy of scheduled data on drawings.
6. Indicate actual equipment proposed, where data sheets indicate more than one (1) device or equipment.

H. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division or other Divisions of this Specification.

I. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a 1/4" = 1'-0" installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance.

This 1/4" = 1'-0" fabrication drawing shall be submitted, for review by the Architect, Engineer, and Owner's Representative, with the shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

J. Submittals and one (1) resubmittal will be reviewed by the Architect/Engineer. If the Contractor fails to provide the required data with his second submittal, he will be charged for the third and subsequent reviews.

K. The Contractor shall submit amount of copies and type, electronic or hard copies, of submittal brochures for review per Division 1 requirements. Brochures shall be submitted within thirty (30) days after contract award. Copies of all submittals will be retained by the Architect, Engineer, and Owner's Representative. Additional copies of submittals, if required by the Contractor, shall be reproduced by the Contractor from the reviewed and marked sets returned to the Contractor.

1.12 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer’s printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.13 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1, Section "PROJECT COORDINATION", to a scale of 1/4" = 1'-0" or larger; detailing major elements, components, and systems of electrical 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 major raceway systems, equipment, and materials. Include the following:
    a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
    b. Exterior wall and foundation penetrations.
    c. Fire-rated wall and floor penetrations.
    d. Equipment connections and support details.
    e. Sizes and location of required concrete pads and bases.
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.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, luminaires, communications systems components, sprinklers, and other ceiling-mounted devices.
5. Provide the coordination drawing electronically.

1.14 USE OF CAD FILES

A. Under certain conditions, the Contractor will be permitted the use of the Engineer's REVIT model/files for documentation of as-builts, submittals, or coordination drawings.

B. The Engineer shall be compensated for the time required to format the REVIT model/files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.

1.15 DRAWINGS AND SPECIFICATIONS

A. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and work of the other sections shall permit. Size and location of equipment is drawn to scale wherever possible. **Do not scale from electrical drawings.**

B. Drawings and specifications are for the assistance and guidance of the Contractor. Exact locations, distances, and levels will be governed by the building. The Contractor shall make use of data in all the Contract Documents to verify information at the building site.

C. In any case where there appears to be a conflict between that which is shown on the electrical drawings, and that shown in any other part of the Contract Documents, the Contractor shall notify and secure directions from the Architect.

D. Drawings and specifications are intended to complement each other. Where a conflict exists between the requirements of the drawings and/or the specifications, request clarification. Do not proceed with work without direction.

E. The Architect shall interpret the drawings and the specifications. The Architect's interpretation as to the true intent and meaning thereof and the quality, quantity, and sufficiency of the materials and workmanship furnished there under shall be accepted as final and conclusive.

F. In the case of conflicts not clarified prior to the bidding deadline, use the most costly alternative (better quality, greater quantity, and larger size in meeting design intent and code requirements) in preparing the bid. A clarification will be issued to the successful bidder as soon as feasible after the award and, if appropriate, a deductive change order will be issued.

G. Where items are specified in the singular, this division shall provide the quantity as shown on drawings plus any spares or extras indicated on the drawings or in the specifications.

H. Investigate structural and finish conditions and arrange work accordingly. Provide all fittings, equipment, and accessories required for actual conditions.

1.16 SIMILAR MATERIALS

A. All items of a similar type shall be products of the same manufacturer.

B. Contractor shall coordinate among suppliers of various equipment to assure that similar equipment type is product of the same manufacturer.

C. Examples of similar equipment types include but are not limited to:

1. Power Circuit Breakers
2. Enclosed Case Circuit Breakers
3. Batteries
4. SPD
5. Motor Starters
6. Transformers
7. Panelboards
8. Disconnects

9. Fuses

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.18 GUARANTEE-WARRANTY

A. See Division 1 for warranties.

B. The following guarantee is a part of the specifications and shall be binding on the Contractor:

> "The Contractor guarantees that this installation is free from ALL defects. He agrees to replace or repair any part of the installation which may fail within a period of one (1) year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date to be determined in writing by means of issuing a 'Certificate of Substantial Completion', AIA Form G704."

C. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

D. All items of electrical equipment furnished and installed under Division 26 shall be provided with a full two (2) year parts and labor warranty.

PART 2 PRODUCTS

2.01 QUALITY OF MATERIALS

A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of electrical equipment, and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.

B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.02 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of this project site in feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

Contractor to verify elevation prior to ordering of any electrical equipment.

2.03 EQUIPMENT REQUIREMENTS

A. The electrical requirements for equipment specified or indicated on the drawings are based on information available at the time of design. If equipment furnished for installation has electrical requirements other than those indicated on the electrical drawings, make all adjustments to wire and conduit size, controls, over current protection and installation as required to accommodate the equipment supplied. Delineate all adjustments to the drawings reflecting the electrical system in a submittal to the Contract Administrator immediately upon knowledge of the required adjustment.

B. Approved Equipment and Conductors: ALL equipment and conductors shall be listed and labeled by a nationally recognized testing laboratory (NRTL). The NRTL shall be listed by the federal occupational safety and health administration. Conformance with the State of New Mexico Electrical Code article 110.2 is required for ALL equipment and conductors.

PART 3 EXECUTION

3.01 COOPERATION WITH OTHER TRADES

A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and
accuracy of all openings. All coordination between trades will occur prior to commencement of any work.

3.02 DRAWINGS

A. The electrical drawings show the general arrangement of all lighting, power, special systems, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents shall be considered as part of the work. Coordinate with architectural, mechanical, and structural drawings. Because of the small scale of the electrical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Provide all fittings, boxes, and accessories as may be required to meet actual

conditions. Should conditions necessitate a rearrangement of equipment, such departures and the reasons therefore, shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No changes shall be made without the prior written approval. All changes shall be marked on record drawings.

B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.

C. Installation of all equipment shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearance, as defined by the National Electrical Code (NEC).

D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 26 with the associated architectural, structural, and mechanical work than is normally necessary for a more typical facility.

E. The installation of all concealed electrical systems shall be carefully arranged to fit within the available space without interference with adjacent structural and mechanical systems.

3.03 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical system, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with all other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in all other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and

equipment to provide the maximum clearance possible.

7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Branch circuits throughout facility to have an individual neutral for each phase for branch circuits.
9. Install 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, refer conflict to the Architect.
10. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
11. Install electrical 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.
12. Install access panel or doors where units are concealed behind finished surfaces.
13. Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.

3.04 FIELD MEASUREMENTS

A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.05 EQUIPMENT SUPPORT

A. Provide support for equipment to the building structure. Provide all necessary structures, inserts,

sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Architect that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.06 PAINTING

A. All finish painting of electrical systems and equipment will be under "Painting," unless equipment is hereinafter specified to be painted.

B. All equipment shall be provided with factory applied standard finish, unless otherwise specified.

C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished to the satisfaction of the Architect and Owner's Representative.

3.07 SEISMIC SUPPORTS

A. See Section 26 0548 for requirements for seismic supporting of electrical equipment and systems.

3.08 PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.

B. All items of electrical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner approved by the Architect and Owner's Representative.

C. The Contractor shall provide protection for all work and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect and Owner's Representative prior to such storage.

D. Conduit openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, luminaires, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect.

3.09 EXCAVATION

A. Provide all excavation, trenching and backfilling required.

B. Slope sides of excavations to comply with codes and ordinances. Shore and brace as required for stability of excavation.

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS "Structural Welding Code."

3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.12 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturer’s printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Firestopping Sealant: Provide sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply

with installation requirements established by testing and inspecting agency.

3.13 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

3.14 CUTTING AND PATCHING

A. Perform cutting and patching in accordance with Division 1, Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
    a. Remove and replace defective Work.
    b. Remove and replace Work not conforming to requirements of the Contract Documents.
    c. Remove samples of installed Work as specified for testing.
    d. Install equipment and materials in existing structures.
    e. Upon written instructions from the Contracting Officer, uncover and restore Work to provide for Contracting Officer observation of concealed Work.
2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. During cutting and patching operations, protect adjacent installations.
6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers.

3.15 MANUFACTURER'S INSTRUCTIONS

A. All equipment shall be installed in strict accordance with recommendations of the manufacturer.

If such recommendations conflict with plans and specifications, the Contractor shall submit such conflicts to the Architect who shall make such compromises as he deems necessary and desirable.

3.16 CONCRETE BASES AND HOUSEKEEPING PADS

A. Install concrete bases and housekeeping pads under all freestanding electrical equipment unless otherwise noted.

B. Contractor shall be responsible for the accurate dimensions of all pads and bases and shall furnish and install all anchor bolts, etc. Coordinate weight of concrete bases and housekeeping pads with the structural engineer.

C. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these specifications. Pad foundations shall be 4" high minimum, unless otherwise indicated on the drawings. Chamfer edges shall be 1". Faces shall be free of voids and rubbed smooth with Carborundum block after stripping forms. Tops shall be level. Provide dowel rods or other required material in floor for lateral stability and anchorage.

3.17 TESTS

A. All tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect one week in advance of all tests. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.18 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Refer to specification section 01 7900 – Demonstration and Training for additional requirements.

1. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the electrical systems and equipment for a period of three (3) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.

2. The Contractor shall video tape the instruction and training sessions using a DVD recorder, and at the completion and acceptance (by Owner and Architect) of the training sessions, the Contractor shall submit (4) copies of the video the recordings.

3.19 INTERRUPTING SERVICES

A. The Contractor will coordinate the installation of all work in the building and on the project site in order to minimize interference with the operation of existing facilities electrical, telephone, fire alarm/protection, and utility systems during construction. Connections to existing systems requiring the interruption of services to existing on site facilities shall be carefully coordinated with the Owner and associated utility companies representative to minimize system downtimes.

B. Requests for the interruption of existing services shall be coordinated by contractor with Owner and submitted in writing a minimum of two (2) weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without the written review.

3.20 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems installed by the Contractor, for the benefit of the Contractor, except for the purposes of testing and balancing will not be permitted without a written agreement between the Owner, Architect, and the Contractor establishing warranty and other responsibilities.

3.21 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The Architect/Engineer will make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation by the Architect/Engineer however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities, nor shall the Architect/Engineer have authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION

LICENSE, INDEMNITY AND WARRANTY AGREEMENT

BETWEEN: Bridgers & Paxton Consulting Engineers, Inc.
4600-C Montgomery Blvd NE
Albuquerque, New Mexico 87109

and the Contractor:

For use of BIM Database by the Contractor for:

PROJECT:_____

LICENSE:_____

1.1 LICENSE GRANT: The Contractor is granted use of the BIM Database for the specific purpose of preparing submittal documents for the Project. No other use of the BIM Database is granted. Title to the BIM Database is not transferred to the Contractor.

1.2 COPYING RESTRICTIONS: The Contractor may copy the BIM Database in whole or in part, only for backup and archival purposes and for use by the Contractor's Subcontractors. All of the Contractor's Subcontractors who receive a copy of the BIM Database in whole or in part shall be bound by the terms and conditions of this Agreement.

1.3 TRANSFER OF BIM DATABASE: The Contractor may not transfer the BIM Database to any other party other than as specified in Section 1.2 of this Agreement.

WARRANTY

2.1 DATABASE WARRANTY: Bridgers & Paxton Consulting Engineers, Inc. disclaims all warranties with regard to the database supplied hereunder, including all implied warranties of fitness. Bridgers & Paxton Consulting Engineers, Inc., disclaims all obligations or liabilities for damages, including, but not limited to, consequential damages rising out of or in connection with the use of performance of the database.

INDEMNITY

3.1 INDEMNITY: The Contractor recognizes that the use of the database will be at the Contractor's sole risk and without any liability, risk or legal exposure by Bridgers & Paxton Consulting Engineers, Inc. The Contractor recognizes that it is impossible for the Engineer to assure the accuracy, completeness and sufficiency of such information, either because it is impossible to verify, or because of errors or omissions which may have occurred in assembling the information the Engineer is providing. Furthermore, in that these BIM Database files are considered to be information furnished to the Contractor by others, it shall be the Contractor's sole responsibility to verify dimensions in the drawings prior to using these database files for his intended purpose. Furthermore, the Contractor shall, to the fullest extent permitted by law, defend, indemnify and hold harmless Bridgers & Paxton Consulting Engineers, Inc., from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the database.

COMPENSATION

3.2 COMPENSATION: The Contractor shall compensate Bridgers & Paxton for the time required to format the BIM files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc. No time shall be expended making any substantive changes to the drawings. The cost for this time will be billed at the rate of $75.00 / Hour. It is not anticipated that more than four (4) hours will be required to complete this task. An invoice will be generated and delivered with the drawing files. Payment for the services shall be made within thirty (30) days of the receipt of the invoice.

ACKNOWLEDGMENT

4.1 ACKNOWLEDGMENT: The Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Authorized Signature: _____

Title: _____

Date: _____

BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.

Authorized Signature: _____

Title: _____

Date: _____

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

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. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 26, Section 26 0529, Hangers and Supports for Electrical Systems for supports and anchors for fastening cable directly to building finishes.
2. Division 26, Section 26 0553, Identification for Electrical Systems for insulation color coding and wire and cable markers.

1.03 INFORMATIONAL SUBMITTALS

A. Field test reports indicating and interpreting test results relative to compliance with performance requirements of testing standard.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

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

1. Alpha Wire Company.

2. American Bare Conductor.
3. Belden Inc.
4. Cerro Wire LLC.
5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Okonite Company (The).
8. Service Wire Co.
9. Southwire Company.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and/or ASTM B 496 for stranded conductors.

E. Conductor Insulation:
1. Type NM: Comply with UL 83 and UL 719.
2. Type THHN and Type THWN-2: Comply with UL 83.

F. Shield:
1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.02 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.

4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSi Industries LLC.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Service Wire Co.
10. TE Connectivity Ltd.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper.
2. Type: Two hole with standard barrels.
3. Termination: Compression.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 12 AWG **minimum**; stranded for No. 10 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground:
Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway, Underground feeder cable, Type UF.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Minimum size conductor to install throughout will be No. 12 AWG.

B. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

C. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

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. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

H. Complete cable tray systems installation according to Section 270536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 8413 "Penetration Firestopping."

3.08 FIELD QUALITY CONTROL

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

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:
    a. Electrical distribution equipment.
    b. Wiring devices
    c. Mechanical and Plumbing equipment
    d. Pool equipment
    e. Kitchen and Concessions Equipment
    f. Bowling Alley Equipment.
    g. Site equipment
3. Perform each of the following visual and electrical tests:

a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
b. Test bolted connections for high resistance using one of the following:
    1) A low-resistance ohmmeter.
    2) Calibrated torque wrench.
    3) Thermographic survey.
c. Inspect compression-applied connectors for correct cable match and indentation.
d. Inspect for correct identification.
e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

4. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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 grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.03 ACTION SUBMITTALS

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

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
    a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
        1) Test wells.
        2) Ground rods.
        3) Ground rings.
        4) Grounding arrangements and connections for separately derived systems.
    b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems, electrical equipment, based on NETA MTS and NFPA 70B.
        1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
        2) Include recommended testing intervals.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Comply with UL 467 for grounding and bonding materials and equipment.

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Burndy; Part of Hubbell Electrical Systems.
    2. Dossert; AFL Telecommunications LLC.
    3. ERICO International Corporation.
    4. Fushi Copperweld Inc.

5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning & Grounding.
7. ILSCO.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Robbins Lightning, Inc.
10. SIEMENS Industry, Inc.; Energy Management Division.

2.03 CONDUCTORS

A. Insulated Conductors: **Copper** wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.04 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper**, copper lugs**. Rated for 600 A.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
    a. Material: Die-cast zinc alloy.
    b. Listed for direct burial.
2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.05 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4 inch by 10 feet.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturers recommended material.

C. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of doorframe, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.02 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.03 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.04 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, no shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.05 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

F. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than **No. 8** AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.06 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use exothermic welds for all below-grade connections.

3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 30 feet of bare copper conductor not smaller than No. 2/0 AWG.

1. If concrete foundation is less than 30 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

L. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

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

E. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

F. Grounding system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 1**0** ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: **5** ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: **3** ohms.

4. Power Distribution Units or Panelboards Serving Electronic Equipment: **3** ohms.

I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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:
   1. Steel slotted support systems.
   2. Aluminum slotted support systems.
   3. Nonmetallic slotted support systems.
   4. Conduit and cable support devices.
   5. Support for conductors in vertical conduit.
   6. Structural steel for fabricated supports and restraints.
   7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
   8. Fabricated metal equipment support assemblies.

B. Related Requirements:
   1. Section 26 0548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
      a. Slotted support systems, hardware, and accessories.
      b. Clamps.
      c. Hangers.
      d. Sockets.

e. Eye nuts.

f. Fasteners.

g. Anchors.

h. Saddles.

i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.

2. Slotted support systems.

3. Equipment supports.

4. 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 hangers and supports for electrical systems.

1. Include design calculations and details of hangers.

2. Include design calculations for seismic restraints.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.

2. Ductwork, piping, fittings, and supports.

3. Structural members to which hangers and supports will be attached.

4. Size and location of initial access modules for acoustical tile.

5. Items penetrating finished ceiling, including the following:

a. Luminaires.

b. Air outlets and inlets.

c. Speakers.

d. Sprinklers.

e. Access panels.

f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.05 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: 1.0.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    a. Allied Tube & Conduit; a part of Atkore International.
    b. B-line, an Eaton business.
    c. ERICO International Corporation.
    d. Flex-Strut Inc.
    e. GS Metals Corp.
    f. G-Strut.
    g. Haydon Corporation.
    h. Metal Ties Innovation.
    i. Thomas & Betts Corporation; A Member of the ABB Group.
    j. Unistrut; Part of Atkore International.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Plain steel.
4. Channel Width: Select size pf channel width for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as

required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    a. Manufacturers: Subject to compliance with requirements**,** available manufacturers offering products that may be incorporated into the Work include the following:
        1) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **s**teel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
        1) B-line, an Eaton business.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All Stainless-steel springhead type.
7. Hanger Rods: Threaded steel.

2.03 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 EXECUTION

3.01 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA 1.
   2. NECA 101
   3. NECA 102.
   4. NECA 105.
   5. NECA 111.

B. Comply with requirements in Section 07 8400 "Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacing’s that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. 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.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.

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

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 5000 "Metal Fabrications" for site-fabricated metal supports.

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

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 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 minimum 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 3000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 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. Touchup: Comply with requirements in Section 09 9113 "Exterior Painting", Section 09 9123 "Interior Painting", and Section 09 9600 "High-Performance Coatings" painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. 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 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

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:
   1. Metal conduits and fittings.
   2. Nonmetallic conduits and fittings.
   3. Metal wireways and auxiliary gutters.
   4. Nonmetal wireways and auxiliary gutters.
   5. Surface raceways.
   6. Boxes, enclosures, and cabinets.
   7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:
   1. Section 07 8400 "Firestopping" for firestopping at conduit and box entrances.
   2. Section 26 0543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
   3. Section 27 0528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
   4. Section 28 0528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.03 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Sustainable Design Submittals:

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways, nonmetallic wireways, surface raceways, and for each color and texture specified, 12 inches long.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 PRODUCTS

2.01 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AFC Cable Systems; a part of Atkore International.
    b. Allied Tube & Conduit; a part of Atkore International.
    c. Anamet Electrical, Inc.
    d. Calconduit.
    e. Electri-Flex Company.
    f. FSR Inc.
    g. Korkap.
    h. Opti-Com Manufacturing Network, Inc (OMNI).
    i. O-Z/Gedney; a brand of Emerson Industrial Automation.
    j. Patriot Aluminum Products, LLC.
    k. Perma-Cote.
    l. Picoma Industries, Inc.
    m. Plasti-Bond.
    n. Republic Conduit.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.

B. Metal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AFC Cable Systems; a part of Atkore International.
    b. Allied Tube & Conduit; a part of Atkore International.
    c. Anamet Electrical, Inc.
    d. Calconduit.
    e. Electri-Flex Company.
    f. FSR Inc.
    g. Korkap.
    h. Opti-Com Manufacturing Network, Inc (OMNI).

i. O-Z/Gedney; a brand of Emerson Industrial Automation.
j. Patriot Aluminum Products, LLC.
k. Perma-Cote.
l. Picoma Industries, Inc.
m. Plasti-Bond.
n. Republic Conduit.

2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
   a. Material: die cast.
   b. Type: compression.
7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Anamet Electrical, Inc.
   c. Arnco Corporation.
   d. CANTEX INC.

e. CertainTeed Corporation.
f. Champion Fiberglass, Inc.
g. Condux International, Inc.
h. Electri-Flex Company.
i. FRE Composites.
j. Kraloy.
k. Lamson & Sessions.
l. Niedax Inc.
m. RACO; Hubbell.
n. Thomas & Betts Corporation; A Member of the ABB Group.

2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fiberglass:
   a. Comply with NEMA TC 14.
   b. Comply with UL 2515 for aboveground raceways.
   c. Comply with UL 2420 for belowground raceways.
4. ENT: Comply with NEMA TC 13 and UL 1653.
5. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
6. LFNC: Comply with UL 1660.
7. Rigid HDPE: Comply with UL 651A.
8. Continuous HDPE: Comply with UL 651A.
9. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
10. RTRC: Comply with UL 2515A and NEMA TC 14.

B. Nonmetallic Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Anamet Electrical, Inc.
   c. Arnco Corporation.

d. CANTEX INC.
e. CertainTeed Corporation.
f. Champion Fiberglass, Inc.
g. Condux International, Inc.
h. Electri-Flex Company.
i. FRE Composites.
j. Kraloy.
k. Lamson & Sessions.
l. Niedax Inc.
m. RACO; Hubbell.
n. Thomas & Betts Corporation; A Member of the ABB Group.

2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
   a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.03 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. Hoffman; a brand of Pentair Equipment Protection.
   3. MonoSystems, Inc.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R, Type 12 unless otherwise indicated, and sized according to NFPA 70.
   1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type, Flanged-and-casketed type in wet or damp locations unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.04 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect, or Prime coated and ready for field painting.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Hubbell Incorporated; Wiring Device-Kellems.
    b. MonoSystems, Inc.
    c. Panduit Corp.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Hubbell Incorporated.
    b. MonoSystems, Inc.
    c. Panduit Corp.

2.05 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Crouse-Hinds, an Eaton business.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.

6. Hoffman; a brand of Pentair Equipment Protection.
7. Hubbell Incorporated.
8. Hubbell Incorporated; Wiring Device-Kellems.
9. Kraloy.
10. Milbank Manufacturing Co.
11. MonoSystems, Inc.
12. Oldcastle Enclosure Solutions.
13. O-Z/Gedney; a brand of Emerson Industrial Automation.
14. Plasti-Bond.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep or 4 inches by 2-1/8 inches by 2-1/8 inches deep depending of device space requirements.

M. Gangable boxes are allowed.

N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 12, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. NEMA 250, Type 1, Type 3R, Type 12, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.06 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

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

b. Armorcast Products Company.
c. NewBasis.
d. Oldcastle Enclosure Solutions.
e. Oldcastle Precast, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, “ELECTRIC" or other systems as indicated on plans.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 12 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.07 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC, Type EPC-40-PVC, and Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: GRC
3. Underground Conduit: RNC, Type EPC-40-PVC. Concrete encased below drive and roadways.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC Raceway locations include the following:
a. Loading dock.
b. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: **3/4-inch** trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression cast-metal fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.02 INSTALLATION

A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. 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.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Approval of structural engineer will be required to install any conduits in slabs. The raceways will be installed per the structural engineer’s requirements. The following are minimums if structural engineer does not provide installation requirements:

a. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.

b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
c. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
d. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
e. Change from ENT to GRC before rising above floor.

M. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

S. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

T. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

V. Surface Raceways:
1. Install surface raceway with a minimum 2-inchradius control at bend points.

2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

W. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

X. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

Y. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Z. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

AA. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

BB. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of outlet for installations greater than 3’-0” and to bottom of outlet for installations less than 3’-0” of box unless otherwise indicated.

CC. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

DD. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

EE. Locate boxes so that cover or plate will not span different building finishes.

FF. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

GG. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

HH. Set metal floor boxes level and flush with finished floor surface.

II. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 31 2000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 31 2000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 31 2000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

3.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install hand holes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install hand holes with bottom below frost line at this project site. Contractor will verify frost line below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.05 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.06 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8400 "Firestopping."

3.07 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

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:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High-density plastic boxes.
10. Precast manholes.
11. Cast-in-place manholes.
12. Utility structure accessories.

1.03 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Traffic ways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include duct-bank materials, including spacers and miscellaneous components.
   2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Include accessories for manholes, handholes, boxes, and other utility structures.
   4. Include underground-line warning tape.
   5. Include warning planks.

B. Shop Drawings:
   1. Precast or Factory-Fabricated Underground Utility Structures:
      a. Include plans, elevations, sections, details, attachments to other work, and accessories.
      b. Include duct entry provisions, including locations and duct sizes.
      c. Include reinforcement details.
      d. Include frame and cover design and manhole chimneys.
      e. Include ladder details.
      f. Include grounding details.
      g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
      h. Include joint details.
   2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
      a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
      b. Include duct entry provisions, including locations and duct sizes.
      c. Include cover design.
      d. Include grounding details.
      e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show 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. Drawings shall be signed and sealed by a qualified professional engineer.

B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

D. Source quality-control reports.

E. Field quality-control reports.

1.06 MAINTENANCE MATERIALS SUBMITTALS

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

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to **5** percent of quantity of each item installed.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.08 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Architect, Construction Manager, Owner no fewer than two weeks in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Architect's, written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 PRODUCTS

2.01 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

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

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
4. Calconduit.
5. Electri-Flex Company.
6. FSR Inc.
7. Korkap.
8. Opti-Com Manufacturing Network, Inc (OMNI).
9. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. Perma-Cote.
11. Picoma Industries, Inc.
12. Plasti-Bond.
13. Republic Conduit.
14. Southwire Company.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.02 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

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

1. ARNCO Corp.

2. Beck Manufacturing.
3. CANTEX INC.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. Crown Line Plastics.
7. ElecSys, Inc.
8. Electri-Flex Company.
9. Endot Industries Inc.
10. IPEX USA LLC.
11. Lamson & Sessions.
12. Manhattan/CDT.
13. National Pipe & Plastics.
14. Opti-Com Manufacturing Network, Inc (OMNI).

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.03 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Allied Tube & Conduit; a part of Atkore International.
    b. CANTEX INC.
    c. Carlon; a brand of Thomas & Betts Corporation.
    d. IPEX USA LLC.
    e. PenCell Plastics.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

1. Color: Red dye added to concrete during batching.
2. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.04 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast, Inc.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

F. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

G. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

H. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

I. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

J. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

K. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

1. Extension shall provide increased depth of 12 inches.
2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

L. 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.

M. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Center window location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

N. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

O. Handholes 12 inches wide by 12 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.05 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armorcast Products Company.
   2. NewBasis.
   3. Oldcastle Enclosure Solutions.

C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

D. Color: Green.

E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

K. Handholes 12 inches wide by 12 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.06 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
   1. Tests of materials shall be performed by an independent testing agency.
   2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
   3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 EXECUTION

3.01 PREPARATION

A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.02 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.

D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

E. Underground Ducts Crossing Driveways and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

3.03 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.

2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Cover design load shall not exceed the design load of the handhole or box.

3.04 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 2000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 9200 "Turf and Grasses" and Section 32 9300 "Plants."
E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 7300 "Execution."

3.05 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
B. Install duct according to NEMA TCB 2.
C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
   1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, 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 slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. 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.
7. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
        1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form sidewalls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, 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 a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 3000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 2000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.

2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. 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.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
        1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
        1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

11. After installing first tier of duct, 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 duct 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. Comply with requirements in Section 31 2000 "Earth Moving" for installation of backfill materials.
    a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
    b. Place minimum 6 inches of engineered fill above concrete encasement of duct.

N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

O. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 0553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.06 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

A. Precast Concrete Handhole Installation:
    1. Comply with ASTM C 891 unless otherwise indicated.
    2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
    3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Install handholes with bottom below frost line. Contractor will verify frost line at this project and depth below grade.
2. Handhole Covers: In paved areas and traffic ways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07. After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Damp proofing: Apply damp proofing to exterior surfaces of and handholes after concrete has cured at least three days. Damp proofing materials and installation are specified by Division 07. After ducts are connected and grouted, and before backfilling, damp proof joints and connections, and touch up abrasions and scars. Damp proof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.07 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 duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and traffic ways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line. Contractor will verify frost line at this project site and dimension below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for duct 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.

G. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screwed to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Section 03 3000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.08 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
   2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
   3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.
   1. Sweep floor, removing dirt and debris.
   2. Remove foreign material.

END OF SECTION

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
   3. Sleeve-seal fittings.
   4. Grout.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 07 8400 "Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:
   1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
    a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

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

2.04 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

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

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

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 9200 "Joint Sealants."

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 0550 - INSTALLATION COORDINATION

PART 1 GENERAL

1.01 REQUIREMENTS

A. See Division 21, Section 21 0549, Fire Protection and Electrical Installation Coordination.

B. See Division 22, Section 22 0549, Plumbing & Electrical Installation Coordination.

C. See Division 23, Section 23 0549, HVAC and Electrical Installation Coordination.

D. See Mechanical Drawings for control requirements and for items requiring 120V power.

PART 2 PRODUCTS

Not applicable.

PART 3 EXECUTION

Not applicable.

END OF SECTION

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

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:
   1. Color and legend requirements for raceways, conductors, and warning labels and signs.
   2. Labels.
   3. Bands and tubes.
   4. Tapes and stencils.
   5. Tags.
   6. Signs.
   7. Cable ties.
   8. Paint for identification.
   9. Fasteners for labels and signs.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 26 0574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.02 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.

2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit, conductors.

1. Color shall be factory applied No. 12 AWG.

2. Colors for 208/120-V Circuits:

a. Phase A: Black.

b. Phase B: Red.

c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.

b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.

b. Phase B: Orange.

c. Phase C: Yellow.

5. Color for 120/208V Neutral White.
6. Color for 277/480V Neutral Grey
7. Color for Equipment Grounds**:** Green.
8. Colors for Isolated Grounds: Green with yellow stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:

1. Black letters on a white field.
2. Label all electrical distribution equipment down to 100A.

2.03 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Champion America.
   c. emedco.
   d. Grafoplast Wire Markers.
   e. HellermannTyton.
   f. LEM Products Inc.
   g. Marking Services, Inc.
   h. Panduit Corp.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. HellermannTyton.
      c. Marking Services, Inc.
      d. Panduit Corp.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A'n D Cable Products.
      b. Brady Corporation.
      c. Brother International Corporation.
      d. emedco.
      e. Grafoplast Wire Markers.
      f. Ideal Industries, Inc.
      g. LEM Products Inc.
      h. Marking Services, Inc.
      i. Panduit Corp.
   2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
   3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
   4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A'n D Cable Products.
b. Brady Corporation.
c. Brother International Corporation.
d. emedco.
e. Grafoplast Wire Markers.
f. HellermannTyton.
g. Ideal Industries, Inc.
h. LEM Products Inc.
i. Marking Services, Inc.
j. Panduit Corp.

2. Minimum Nominal Size:
a. 1-1/2 by 6 inches for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

2.04 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Brady Corporation.

2.05 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Carlton Industries, LP.
      b. Champion America.
      c. HellermannTyton.
      d. Ideal Industries, Inc.
      e. Marking Services, Inc.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. emedco.

C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. HellermannTyton.
      b. LEM Products Inc.
      c. Marking Services, Inc.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Carlton Industries, LP.

E. Underground-Line Warning Tape:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
d. Marking Services, Inc.
e. Reef Industries, Inc.

2. Tape:
a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:
a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag: Type II:
a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Thickness: 12 mils.
d. Weight: 36.1 lb/1000 sq. ft.
e. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be **1 inch**.

2.06 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Brady Corporation.
    b. Carlton Industries, LP.
    c. emedco.
    d. Marking Services, Inc.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Brady Corporation.
    b. Carlton Industries, LP.
    c. emedco.
    d. Grafoplast Wire Markers.
    e. LEM Products Inc.
    f. Marking Services, Inc.
    g. Panduit Corp.

C. Write-on Tags:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Carlton Industries, LP.
    b. LEM Products Inc.
2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.07 SIGNS

A. Baked-Enamel Signs:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Carlton Industries, LP.
      b. Champion America.
      c. emedco.
   2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
   3. 1/4-inch grommets in corners for mounting.
   4. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Champion America.
      c. emedco.
   2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
   3. 1/4-inch grommets in corners for mounting.
   4. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. emedco.
   2. Engraved legend.
   3. Thickness:
      a. For signs up to 20 sq. in., minimum 1/16 inch thick.

b. For signs larger than 20 sq. in., 1/8 inch thick.

c. Engraved legend with Black letters on white face.

d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.

e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.08 CABLE TIES

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

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services, Inc.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.09 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.01 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.02 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Stand-By Power Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER."
2. “STAND-BY POWER”

M. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

W. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
   2. Limit use of underground-line warning tape to direct-buried cables.
   3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Metal Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using plenum-rated cable ties.

Y. Nonmetallic Preprinted Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using plenum-rated cable ties.

Z. Write-on Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using plenum-rated cable ties.

AA. Baked-Enamel Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

CC. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

DD. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.03 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "STAND-BY POWER."
2. "POWER."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around color-coding bands to identify the phase.
   1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

I. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

J. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
    a. Power-transfer switches.
    b. Controls with external control power connections.

P. Arc Flash Warning Labeling: Self-adhesive labels.

Q. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

R. Stand-By Power Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

S. Equipment Identification Labels:

1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:
    a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
    b. Enclosures and electrical cabinets.
    c. Access doors and panels for concealed electrical items.
    d. Switchgear.
    e. Switchboards.
    f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
    g. Substations.
    h. Emergency system boxes and enclosures.
    i. Motor-control centers.
    j. Enclosed switches.
    k. Enclosed circuit breakers.

l. Enclosed controllers.

m. Variable-speed controllers.

n. Push-button stations.

o. Power-transfer equipment.

p. Contactors.

q. Remote-controlled switches, dimmer modules, and control devices.

r. Battery-inverter units.

s. Battery racks.

t. Power-generating units.

u. Monitoring and control equipment.

v. UPS equipment.

END OF SECTION

SECTION 26 0572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

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 a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals **shall** be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.06 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 unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CGI CYME.
   2. EDSA Micro Corporation.
   3. ESA Inc.
   4. Operation Technology, Inc.
   5. Power Analytics, Corporation.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.

3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:
      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.

e. Equivalent impedance.

f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 EXECUTION

3.01 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices 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. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.02 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.
B. Calculate short-circuit currents according to IEEE 551.
C. Base study on the device characteristics supplied by device manufacturer.
D. The extent of the electrical power system to be studied is indicated on Drawings.
E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
   1. Electric utility's supply termination point.
   2. Incoming switchgear.
   3. Unit substation primary and secondary terminals.
   4. Low-voltage switchgear.
   5. Motor-control centers.

6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.

3.03 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.04 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

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 computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

B. Study results shall be used to determine coordination of series-rated devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals **shall** be in digital form.

C. Coordination-study input data, including completed computer program input data sheets.

D. Study and equipment evaluation reports.

E. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

B. In addition to items specified by Division 01 include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.

2) Protective device coordination study.

3) Time-current coordination curves.

b. Power system data.

1.07 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 unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

C. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

E. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

B. SKM

C. Comply with IEEE 242 and IEEE 399.

D. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

E. 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.

F. Optional Features:

a. Arcing faults.

b. Simultaneous faults.

c. Explicit negative sequence.

d. Mutual coupling in zero sequence.

2.02 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

D. Protective device designations and ampere ratings.

E. Cable size and lengths.

F. Transformer kilovolt ampere (kVA) and voltage ratings.

G. Motor and generator designations and kVA ratings.

H. Switchgear, switchboard, motor-control center, and panelboard designations.

I. Study Input Data: As described in "Power System Data" Article.

J. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."

K. Protective Device Coordination Study:

L. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.

        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.

        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).

        2) Adjustable time-current characteristic.

        3) Adjustable instantaneous pickup.

        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

M. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

N. Device tag and title, one-line diagram with legend identifying the portion of the system covered.

O. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

P. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

Q. Plot the following listed characteristic curves, as applicable:

a. Power utility's overcurrent protective device.

b. Medium-voltage equipment overcurrent relays.

c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.

d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.

e. Transformer full-load current, magnetizing inrush current and ANSI through-fault protection curves.

f. Cables and conductors damage curves.

g. Ground-fault protective devices.

h. Motor-starting characteristics and motor damage points.

i. Generator short-circuit decrement curve and generator damage point.

j. The largest feeder circuit breaker in each motor-control center and panelboard.

R. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.

S. Provide adequate time margins between device characteristics such that selective operation is achieved.

T. Comments and recommendations for system improvements.

PART 3 EXECUTION

3.01 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 that have not been submitted and approved prior to coordination study may not be used in study.

3.02 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

F. To normal system low-voltage load buses where fault current is 10 kA or less.

G. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

H. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

I. Transformer Primary Overcurrent Protective Devices:

J. Device shall not operate in response to the following:

    a. Inrush current when first energized.

    b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

    c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

K. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

L. Motor Protection:

M. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

N. Select protection for motors served at voltages more than 600 V according to IEEE 620.

O. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

P. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

Q. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

R. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

S. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

T. Electric utility's supply termination point.

U. Switchgear.

V. Low-voltage switchgear.

W. Standby generators and automatic transfer switches.

X. Branch circuit panelboards.

Y. Protective Device Evaluation:

Z. Evaluate equipment and protective devices and compare to short-circuit ratings.

AA. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

BB. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.03 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

B. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.

C. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.

D. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.04 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.05 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

B. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.

C. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

D. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

E. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

F. Product Data for overcurrent protective devices specified in other 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.

G. Electrical power utility impedance at the service.

H. Power sources and ties.

I. Short-circuit current at each system bus, three phase and line-to-ground.

J. Full-load current of all loads.

K. Voltage level at each bus.

L. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

M. For reactors, provide manufacturer and model designation, voltage rating, and impedance.

N. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

O. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

P. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.

Q. Maximum demands from service meters.

R. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

S. Motor horsepower and NEMA MG 1 code letter designation.

T. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).

U. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

V. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.

    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

    d. Generator thermal-damage curve.

    e. Ratings, types, and settings of utility company's overcurrent protective devices.

    f. Special overcurrent protective device settings or types stipulated by utility company.

    g. Time-current-characteristic curves of devices indicated to be coordinated.

    h. 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.

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.06 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

D. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.07 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

B. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.

C. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.

D. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

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 a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in

equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
2. Operation and Maintenance Procedures: In addition to items specified by Division 01, provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.07 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 unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member

company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

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. CGI CYME.
   2. EDSA Micro Corporation.
   3. ESA Inc.
   4. Operation Technology, Inc.
   5. Power Analytics, Corporation.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.02 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.03 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.02 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.03 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other 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. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.04 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
   1. Motor-control center.
   2. Low-voltage switchboard.
   3. Switchgear.

4. Medium-voltage switch.
5. Control panel.

3.05 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.06 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 0800 - ELECTRICAL FACILITY STARTUP/COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope Of The Work

1. The purpose of this section is to specify Division 26 responsibilities and participation in the commissioning process. The owner will hire the Commissioning Authority for the project.
2. The Contractor is responsible to provide support required for start-up, testing, and commissioning. The commissioning process requires significant participation of Division 26 to ensure all portions of the work have been completed in a satisfactory and fully operational manner.

B. Minimum requirements for Contractor:

1. Start-up and testing of the equipment supplied.
2. Operate and maintain equipment and systems as required for commissioning tests.
3. Providing qualified personnel including equipment manufacturer's service technicians for participation with the commissioning team.
4. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
5. Provide operation and maintenance information and record drawings for verification, organization, and distribution.
6. Provide assistance to the Commissioning Authority (CA) to develop and edit equipment startup and testing schedules (Commissioning Matrix).
7. Provide training for the systems specified in this division with coordination by the Contract Administrator and Commissioning Authority.
8. Attend commissioning meetings.

1.02 RELATED WORK

A. All start-up and testing procedures and documentation requirements specified within Division 26.

B. Allow sufficient time before final commissioning dates so that testing, adjusting and demonstration can be accomplished.

C. Put all electrical gear into full operation only after all testing has been completed, and the Commissioning Authority has received the testing documentation.

D. Provide labor and material to make corrections when required.

1.03 DEFINITIONS

A. Point Verification Forms (PVF) are detailed installation and startup tracking documents developed by the Commissioning Authority and completed through a cooperative effort between the Contractor and the Commissioning Authority. The PVFs will track each point through installation, termination, and connection to the Facility Management System (FMS).

B. Functional Performance Tests (FPT) are detailed testing procedure developed by the Commissioning Authority, and conducted through a cooperative effort between the Contractor and the Commissioning Authority. The FPTs will be detailed step by step procedures developed for each electrical system. The majority of electrical testing will be by the third party electrical testing firm. Commissioning Authority generated FPT's will be for systems such as lighting controls, dimmer controls, etc. Each FPT will have a clear acceptance criteria based in the contract documents which must be achieved before the system or sub-system is accepted by the Commissioning Authority and the Owner.

C. The Commissioning Authority (CA) is a firm hired directly by the Owner to oversee the entire commissioning process.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.01 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the system can be tested, adjusted, and energized. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional and ready for testing and startup. This includes the complete installation of all equipment, materials, conduit, wire, supports, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

B. A commissioning plan will be developed by the CA and approved by the commissioning team. Division 26 is obligated to assist the CA in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system

modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process, notify the Commissioning Authority and Contract Administrator for approval.

C. Specific pre-commissioning responsibilities of Division 26 are as follows:
   1. Bring each system to a fully construction completed state.
   2. Commissioning is intended to begin upon completion of a system. To support Partial Occupancy commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the CA as equipment Early Run. Start of commissioning before system completion will not relieve Division 26 from completing those systems as per the schedule.

3.02 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up all systems within Division 26. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested, coordinated by the CA, and tracked on the Commissioning Matrix. Division 26 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

C. The Contract Administrator and CA reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the commissioning team to complete the job.

3.03 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustment, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Contract Administrator, with input from the

Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Contract Administrator will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit completion of the commissioning process according to the schedule. Experimentation to render system performance will be permitted. If the CA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CA will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.04 TRAINING

A. Participate in the training of the Owner's engineering and maintenance staff, as required in Divisions 26, on each system and related components. Training, in part, will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.

B. Training will be conducted by the Contractor and the equipment vendors.

C. Training for the Commissioning Team members on the Commissioning Plan will be provided by the CA. All Commissioning Team members are required to attend this training.

3.05 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 26, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. Red-line all drawings on two sets. Include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout in Division 26 as-built drawings.

B. Maintain as-built red-lines as required by Division 01. Given the size and complexity of this project, red-line drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory. Maintain these drawings in the construction trailer and make them available for inspection at any time.

3.06 MISCELLANEOUS SUPPORT

A. Division 26 shall remove and replace covers of equipment, open access panels, etc., to permit Contractor, Contract Administrator, or CA to observe equipment and controllers provided.

END OF SECTION

SECTION 26 0880 - ELECTRICAL ACCEPTANCE TESTING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this Section.

B. Refer to individual specification sections indicated below for tests to be performed and other requirements.

1.02 QUALITY ASSURANCE

A. The Contractor shall engage and pay for the services of a recognized independent Electrical Testing Agency for the purpose of performing the independent inspections, tests, adjustments and settings as specified herein and in other sections.

B. The Electrical Testing Agency shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

C. The Electrical Testing Agency shall submit appropriate documentation to demonstrate that it satisfactorily complies with the following. An organization having a “Full Membership” classification issued by the InterNational Electrical Testing Association.

1. The Electrical Testing Agency shall be an independent, third party, testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing organization.
2. The Electrical Testing Agency shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

D. The Electrical Testing Agency shall utilize technicians who are regularly employed for testing services.

E. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make an informed judgment on the continued serviceability or nonserviceability of the specific equipment. Technicians shall be certified in

ANSI/NETA ETT–2000, Standard for Certification of Electrical Testing Technicians. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

1.03 PERFORMANCE CRITERIA

A. Perform acceptance testing, inspection, and calibration to assure that installed electrical systems and equipment, either Owner or Subcontractor supplied are:
   1. Installed in accordance with design Specifications and manufacturer's instructions,
   2. Ready to be energized,
   3. Operational and within industry and manufacturer's tolerances.

B. Refer to each Division 26 specification sections for equipment and systems to be inspected, tested and calibrated by the Electrical Testing Agency.

1.04 REGULATORY REQUIREMENTS

A. Make Inspections and tests in accordance with the applicable codes and standards of the following agencies except as provided otherwise herein:
   1. InterNational Electrical Testing Association – NETA ATS latest Edition: Acceptance Testing Specifications.
   2. ANSI/NETA ETT – 2000, Standard for the Certification of Electrical Testing Technicians
   3. National Fire Protection Association – NFPA.
      a. ANSI/NFPA 70: National Electrical Code.
      b. ANSI/NFP A 70B: Recommended Practice for Electrical Equipment Maintenance.
      c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces.
      d. NFPA 99 & 101.

B. Use the following references:
   1. Project design Specifications.
   2. Project ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY – refer to Section 26 0573.
   3. Manufacturer's instruction manuals applicable to each particular apparatus.
   4. Project list of equipment to be inspected and tested.

1.05 GENERAL REQUIREMENTS

A. Safety and Precautions

This document does not include any procedures, including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Inherent in this determination is the prerequisite that individuals performing these tests be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

1. Safety practices shall include, but are not limited to, the following requirements:
    a. Occupational Safety and Health Act.
    b. Accident Prevention Manual for Industrial Operations, National Safety Council.
    c. Applicable state and local safety operating procedures.
    d. Owner’s safety practices.
    e. ANSI/NFPA 70E, Electrical Safety Requirements for Employee Workplaces.
2. All tests shall be performed with apparatus de-energized except where otherwise specifically required.
3. The Electrical Testing Agency shall have a designated safety representative on the project to supervise operations with respect to safety.

B. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.
2. Split-core current transformers and clamp-on or tong-type ammeters require consideration of the following in regard to accuracy:
    a. Position of the conductor within the core
    b. Clean, tight fit of the core pole faces
    c. Presence of external magnetic fields
    d. Accuracy of the current transformer ratio in addition to the accuracy of the secondary meter.
3. Selection of metering equipment shall be based on knowledge of the waveform of the variable being measured. Digital multimeters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing, RMS scaled meters may be misleading.

4. Field test metering used to check power system meter calibration must have accuracy higher than that of the instrument being checked.
5. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of two percent of the scale used.
6. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

C. Test Instrument Calibration
1. The Electrical Testing Agency shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
3. Instruments shall be calibrated in accordance with the following frequency schedule:
   a. Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
   b. Laboratory instruments: 12 months
   c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.
4. Dated calibration labels shall be visible on all test equipment.
5. Records, which show date and results of instruments calibrated or tested, shall be kept up-to-date.
6. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
7. Calibrating standard shall be of higher accuracy than that of the instrument tested.

D. Test Report
1. The test report shall include the following:
   a. Summary of project.
   b. Description of equipment tested.
   c. Description of test.
   d. Test data.
   e. Analysis and recommendations.
2. Test data records shall include the following minimum requirements:
   a. Identification of the testing organization.
   b. Equipment identification.

c. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
d. Date of inspections, tests, maintenance, and/or calibrations.
e. Identification of the testing technician.
f. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
g. Indication of expected results when calibrations are to be performed.
h. Indication of “as-found” and “as-left” results.
i. Sufficient spaces to allow all results and comments to be indicated.

3. The Electrical Testing Agency shall furnish a copy or copies of the complete report to the owner and Commissioning Authority as required in the acceptance contract.

1.06 SUBMITTALS

A. Qualifications of the Electrical Testing Agency shall be submitted to the COMMISSIONING AUTHORITY for review with the electrical equipment submittals in accordance with Section 260500, "COMMON WORK RESULTS FOR ELECTRICAL, Submittals."

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Set all adjustable circuit breaker trip settings in accordance with the trip setting report from the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.
B. Test, inspect and calibrate the following electrical equipment in strict accordance with applicable sections of NETA ATS-2003.
1. Electrical equipment shown on the electrical Drawings.
2. Electrical equipment specified in all Division 26 Specifications for the Site.
3. Electrical equipment furnished under other Divisions of the Specifications and connected under Division 26.
C. Perform acceptance tests and inspections prior to energizing equipment, unless where energization is required to perform specified tests.

D. Final acceptance will not occur before completion of the electrical acceptance tests, inspections and calibrations specified in this section.

3.02 FIELD QUALITY CONTROL

A. Standards: Comply with applicable standards of the InterNational Electrical Testing Association (NETA), including standard ATS.

B. Acceptance Testing: After installing equipment and BEFORE electrical circuitry has been energized. Demonstrate product capability and compliance with requirements.

3.03 DIVISION OF RESPONSIBILITY

A. The Electrical Testing Agency shall provide all material, equipment, labor and technical supervision to perform such tests and inspections as specified herein.

B. The Electrical Testing Agency is responsible for programming all protective and alarming devices with the proper settings provided by the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY. Settings shall not be changed or applied to any device without written authorization from the Owner.

C. The Electrical Testing Agency shall notify the Commissioning Authority and Owner immediately upon the discovery of any defective equipment or incorrect system design or installation.

D. The Electrical Testing Agency shall provide an experienced person on-site during energizing, with appropriate test equipment to provide assistance in the event of a malfunction during the system start-up process.

3.04 ACCEPTANCE TESTING PROCEDURES

A. Testing and acceptance procedures for the equipment and systems listed in Part 1 shall be as described in the individual equipment specification sections listed above.

END OF SECTION

SECTION 26 0913 - LIGHTING CONTROL EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following types of lighting controls:
   1. Manual and integrated, multi-preset, modular-dimming systems.
   2. Multi-channel, remote-controlled dimming systems.
   3. Programmable, low-voltage lighting control systems.
   4. Time switches.
   5. Photoelectric relays.
   6. Occupancy Sensors
   7. Low-voltage control system components.
   8. Lighting relays and contactors.
   9. Remote-control stations.

B. Related Sections: The following Sections contain requirements that relate to this Section:
   1. Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems, for general component identification and support requirements.
   2. Division 26, Section 26 0553, Identification for Electrical Systems and general identification requirements.

1.03 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product Data for lighting control equipment and systems components, including dimensions and data on features and components. Include wiring diagrams and elevation views of front panels of control and indicating devices. Include data on ratings. For flush control panels, submit color and finish options for selection. Also include the following:

1. Lists of ballast and lamp combinations compatible with dimmer systems, by manufacturer and catalog number.
2. Sound data, including operational tests of dimming systems.
3. Operational documentation for software.

C. Shop Drawings detailing assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

D. Wiring diagrams detailing specific systems tailored to this Project and differentiating between factory-installed and field-installed wiring.

E. Field test reports indicating and interpreting test results specified in Part 3 of this Section.

F. Maintenance data for lighting control equipment and systems components to include in the operation and maintenance manual specified in Division 01.

1.04 QUALITY ASSURANCE

A. Electrical Component Standard: Provide components that comply with NFPA 70 and are listed and labeled by UL where available.

B. Comply with FCC Regulations of Part 15, Subpart J for Class A.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.05 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a written warranty signed by manufacturer and Installer agreeing to replace programmable lighting control system components that fail in materials or workmanship within the specified warranty period.

C. Warranty Period: Two (2) years from date of Substantial Completion.

1.06 EXTRA MATERIALS

A. Furnish extra products as described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents. Deliver extra materials to Owner.
   1. Relays: Single-pole mechanically held, 1 for every 10 installed. Furnish at least one of each type.
   2. Dimmer Modules: 1 for every 10 of each type and rating installed. Furnish at least one of each type.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, 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. Manual and Integrated, Multi-preset, Modular Dimming Systems:
      a. Crestron Electronics, Inc.
      b. Lightolier, Inc.
      c. Lithonia Lighting
      d. Lutron Electronics Co., Inc.
      e. USI Industries, Inc.; Prescolite, Inc.
      f. Wavelinx
   2. Multichannel, Remote-Controlled Dimming Systems:
      a. Colortran, Inc.
      b. Electronics Diversified, Inc.
      c. Lightolier, Inc.
      d. Lithonia Lighting
      e. Lutron Electronics Co., Inc.
      f. Sterner Lighting Systems, Inc.
      g. Strand Lighting
      h. Wavelinx
   3. Programmable, Low-Voltage Lighting Control Systems:

a. Colortran, Inc.
b. Enercon Engineering, Inc.
c. GE Lighting Controls
d. Honeywell, Inc.; Home Building Controls
e. Johnson Controls, Inc.; Controls Group Div.
f. Lithonia Lighting
g. Lutron Electronics Co., Inc.
h. Microlite Corporation
i. Square D Co.
j. Tork, Inc.
k. Wavelinx

4. Contactors and Relays:
   a. Automatic Switch Co.
   b. Challenger Electrical Equipment Corp.
   c. Eaton Corporation, Cutler-Hammer Products
   d. Furnas Electric Co.
   e. GE Lighting Controls
   f. Hubbell Lighting, Inc.
   g. Siemens Energy and Automation, Inc.
   h. Square D Co.
   i. Zenith Controls, Inc.
   j. Wavelinx
5. Time Switches:
   a. Grasslin Controls Corp.
   b. Intermatic, Inc.
   c. Leviton Manufacturing Co., Inc.
   d. Paragon Electric Co., Inc.
   e. Tork, Inc.
   f. Zenith Controls, Inc.
6. Photoelectric Relays:
   a. Allen-Bradley Co, Inc.; Industrial Control Group Div.
   b. Area Lighting Research, Inc.
   c. Control Systems Engineering, Inc.

d. Fisher Pierce
e. Intermatic, Inc.
f. Paragon Electric Co, Inc.
g. Rhodes: MH Rhodes, Inc. (Ripley Photocontrols)
h. SSAC, Inc.
i. Tork, Inc.

2.02 LIGHTING CONTROL EQUIPMENT, GENERAL

A. Include line-voltage surge protection in all solid-state equipment. Comply with UL 1449 and ANSI C62.41.
B. Load Compatibility: Components compatible with each other and with controlled loads.
C. Dimmers and Dimmer Modules: Comply with UL 508.
1. Noise and Radio Frequency Interface (RFI) Suppression: Solid-state dimmers operate smoothly over their operating ranges without audible lamp noise or RFI at any setting. Modules include integral or external filters that provide audible noise and RFI suppression.
2. Dimmer or Dimmer Module Rating: As indicated, but not less than 125 % of connected load.

2.03 MANUAL, MODULAR DIMMING SYSTEMS

A. Description: Factory-fabricated equipment providing 1 to 4 channels of manual dimming control. Integrate controls and dimmers for mounting in a 2- or 3-gang wall box under a single wall plate.
B. Module Dimming Capability: Listed for control of type of lighting unit used.
1. Fluorescent Dimmers: Control lights smoothly over a minimum range of 100 to 1 percent of full brightness.
C. Unit Rating: 1900 W, minimum, with each dimming channel rated 600 W, minimum.

2.04 CONTACTORS AND RELAYS

A. Comply with NEMA ICS 2.
B. Description: Devices are electrically operated and mechanically held. Number of poles and ratings are as indicated. Coordinate rating of each unit with type of load served, including tungsten filament and inductive-type loads.

C. Modular Single-Pole Relays: Split-coil, momentary-pulsed type, knockout mounting.
   1. Low-Voltage Leads: 5-pin plug connector.
   2. Pilot Contacts: Single pole.
   3. Rated Capacity: 20 A, 125 VAC for tungsten filaments, and 20 A, 277 VAC for ballasts.
   4. Endurance: 50,000 cycles at rated capacity.

D. Modular Relay Panels: Steel cabinets preassembled with modular single-pole relays, transformer power supplies, and associated components.
   1. Barriers separate low-voltage and line-voltage components.
   2. Cover: Hinged, lockable type.
   3. Directory: Mounted on back of door. Identifies relays and loads controlled.

2.05 TIME SWITCHES

A. Time Switches: Solid-state programmable units with alphanumeric display conforming to UL 917. Include the following features:

B. Time Switches: Electromechanical-dial type conforming to UL 917. Include the following features:
   1. Astronomic dial.
   2. Contacts: 2, rated 30A at 277 VAC, except as otherwise indicated.
   3. Pilot-Duty Contacts: 2, rated 2A at 240V, except as otherwise indicated.
   4. Eight-Day Program: Uniquely programmable for each day of the week and holidays.
   5. Skip-day mode.

2.06 PHOTOELECTRIC RELAYS

A. Conform to UL 773A.

B. Type: Solid-state, with SPDT dry contacts rated to operate relay or contactor coils to which connected.

C. Time delay prevents false operation.

D. Indoor Ceiling- or Wall-Mounted Units: Semi-flush, calibrated to detect adequacy of daylighting in perimeter locations and arranged to turn artificial illumination on and off to suit varying intensities of available daylighting. Units are adjustable for turn-on/turn-off levels.

E. Indoor Skylight Units: Housed in a threaded plastic fitting for mounting under skylight, suitable for monitoring light levels from 0 to 3500 foot candles (0 to 37 673 lux), with an adjustment for turn-on/turn-off levels.

F. Outdoor Sealed Units: Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.07 OCCUPANCY SENSORS

A. General: Designed for type of mounting and space detection coverage requirements indicated. Connected to receive power from and operate a light switching relay in a separately mounted auxiliary power control unit, except as otherwise indicated.

B. Operation: Turns lights on when room or covered area is occupied and off when unoccupied, except as otherwise indicated.
   1. Time Delay for Turning Lights Off: Adjustable.
   2. Ambient-Light-Level Control: Adjustable to set a level of ambient illumination above which sensor will not energize luminaires.
   3. Isolated Relay Contact: Operates on detection of occupancy to activate an independent function.

C. Auxiliary Power Control Units: Relays are rated for a minimum of 20-A ballast load or 13-A tungsten lamp load. Sensor power supply is rated to supply number of sensor heads to which it is connected.

D. Passive Infrared Type: Occupancy is detected by a combination of heat and movement in zone of coverage. Each sensing head detects occupancy anywhere in an area of 1000 sq. ft. by detecting occurrence of 6-inch minimum movement of any portion of a human body that presents a minimum target of 36 sq. in. to sensor head.

E. Ultrasonic Type: Unit emits a beam of ultrasonic energy and detects occupancy through use of Doppler principal in discerning movement in zone of coverage by sensing a change in pattern of reflected ultrasonic energy.

F. Dual-Technology Type: Unit uses a combination of passive infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in field by operating controls on unit.

2.08 MANUAL SWITCHES AND PLATES

A. Switches: Specification grade, modular, momentary push-button, low-voltage type.
   1. Color: White, except as otherwise indicated.
   2. Integral Pilot Light: Indicates when circuit is on. Use where indicated.

3. Locator Light: Internal illumination helps locate switch in the dark. Use where indicated.
4. Wall Plates: Match those specified in Division 26, Section 26 2726, Wiring Devices, to materials, finish, and color. Use multi-gang plates where more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment according to manufacturers' written instructions.
B. Mount control equipment according to manufacturers' instructions and Division 26, Section 26 2726, Wiring Devices.
C. Mounting heights indicated are to bottom of unit for suspended items and to center of unit for wall-mounted ones.

3.02 CONTROL WIRING INSTALLATION

A. Install wiring between control devices as specified in Division 26 Section 26 2726, Wiring Devices.
B. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems.
C. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceways and Boxes for Electrical Systems, except where run in accessible ceiling space, and gypsum board partitions.
D. Bundle, train, and support wiring in enclosures.
E. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26, Section 26 0553, for Identification for Electrical Systems.

B. Label each system control module with a unique designation. Make designations on elevated components readable from floor.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to test, adjust, and program lighting control systems.

B. Reports: Prepare written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and person.

D. Schedule visual and mechanical inspections and electrical tests with at least 7 days' advance notice.

E. Visual and Operational Inspections: Include the following inspections:

1. Inspect control components for defects and physical damage, NRTL labeling, and nameplate compliance with current Project Drawings.
2. Check tightness of electrical connections with torque wrench calibrated within previous 6 months. Use manufacturers recommended torque values.
3. Verify settings of photoelectric devices with photometer calibrated to National Institute for Science and Technology (NIST) standards within past 6 months.
4. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's instructions for routine functional operation.

F. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following tests according to manufacturer's instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate controls to demonstrate controls in a methodical sequence that cues and reproduces actual operating functions. Include testing of dimming equipment and ambient-light, programmable and occupancy controls under conditions that simulate actual operational conditions. Record control settings, operations, cues and functional observations.

G. Correct deficiencies disclosed by inspections and tests, make necessary adjustments, and retest deficient items. Verify that specified requirements are met.

3.05 ADJUSTING AND CLEANING

A. Occupancy Adjustments: Upon request within 1 year of date of Substantial Completion, make up to 3 on-site visits to Project site to assist in adjusting light levels, making program changes, and adjusting sensors and controls.

B. Repair scratches and mars of finish to match original finish. Clean equipment and devices internally and externally using methods and materials recommended by manufacturers.

3.06 DEMONSTRATION

A. Training: Provide services of a factory-authorized service representative to demonstrate programmable lighting control system and to train Owner's maintenance personnel.

1. Train Owner's personnel to operate, service, maintain, adjust, and program equipment and system components. Allow at least 8 hours to conduct training. Schedule training with at least 7 days' advance notice. Use final approved operation and maintenance manual as a training aid throughout training. Use both classroom training and hands-on exercises.

END OF SECTION

SECTION 26 2413 - SWITCHBOARDS

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:
   1. Service and distribution switchboards rated 600 V and less.
   2. Surge protection devices.
   3. Disconnecting and overcurrent protective devices.
   4. Instrumentation.
   5. Control power.
   6. Accessory components and features.
   7. Identification.
   8. Mimic bus.

1.03 RELATED SECTIONS

A. Section 26 0574 "Overcurrent Protective Device Arc-Flash Study" for arc-flash study and arc-flash label requirements.

1.04 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
   1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
   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.
   2. Detail enclosure types for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

D. Delegated Design Submittal:
1. For arc-flash hazard study.
2. For arc-flash labels.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
1. Test procedures used.
2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified by Division 01 include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.07 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.
C. Handle and prepare switchboards for installation according to **NEMA PB 2.1**.

1.10 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.
C. Unusual Service Conditions: NEMA PB 2, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.
D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Architect, Construction Manager no fewer than 14 days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
   4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

A. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 SWITCHBOARDS

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

1. Square D
2. Eaton.
3. General Electric Company.

4. SIEMENS Industry, Inc.; Energy Management Division.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Section Alignment: Front aligned.

J. Front- and Rear-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel and fixed, individually mounted.
3. Sections front aligned.

K. Nominal System Voltage: 480Y/277 V and 208Y/120 V.

L. Main-Bus Continuous: Amps as indicated on one-line diagram.

M. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

N. Indoor Enclosures: Steel, NEMA 250, Type 1.

O. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

P. Barriers: Between adjacent switchboard sections.

Q. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

R. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

S. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

T. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

U. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

V. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

W. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

X. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.

2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

Y. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
4. Copper feeder circuit-breaker line connections.
5. Tin-plated aluminum feeder circuit-breaker line connections.
6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
7. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
8. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
9. Disconnect Links:
    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
10. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

11. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

Z. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

AA. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

BB. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.03 SURGE PROTECTION DEVICES

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

1. Advanced Protection Technologies Inc. (APT).
2. Eaton.
3. General Electric Company.
4. SIEMENS Industry, Inc.; Energy Management Division.

B. SPDs: Comply with UL 1449, Type 2.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.

D. Features and Accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5A and 250-V ac one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA**.** The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral**:** 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V and 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V and 1000 V for 208Y/120 V.

G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

H. SCCR: Equal or exceed 250 kA.

I. Nominal Rating: 20 kA.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. 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. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long and short time adjustments.
d. Ground-fault pickup level, time delay, and I squared t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).

7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:
    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    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. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 0913 "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
    h. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
    j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 80 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Standard function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
    a. Instantaneous trip.
    b. Time adjustments for long- and short-time pickup.

c. Ground-fault pickup level, time delay, and I squared T response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 26 0913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switchblade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Boltswitch, Inc.
   b. Eaton.
   c. SIEMENS Industry, Inc.; Energy Management Division.
2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
   b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL-1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

a. Configuration**:** Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

E. Fuses are specified in Section 262813 "Fuses."

2.05 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.

e. Megavars: Plus or minus 1 percent.

f. Power Factor: Plus or minus 1 percent.

g. Frequency: Plus or minus 0.1 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.

i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

C. Analog Meters:

1. Meters: 4-inch diameter or 6 inches square, flush or semi flush, with anti-parallax 250-degree scales and external zero adjustment.

D. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

E. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.

2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondary in a closed-circuit condition at all times.

F. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

G. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.

2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.

3. Suitable for connection to three- and four-wire circuits.

4. Potential indicating lamps.

5. Adjustments for light and full load, phase balance, and power factor.

6. Four-dial clock register.

7. Integral demand indicator.

8. Contact devices to operate remote impulse-totalizing demand meter.

9. Ratchets to prevent reverse rotation.

10. Removable meter with draw out test plug.

11. Semi flush mounted case with matching cover.
12. Appropriate multiplier tag.

H. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five-minute integrated demand of totalized system.

2.06 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Control Circuits: 24V dc.

D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondary loads connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.07 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each draw out circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.08 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.

1. Nameplate: At least 0.032-inch-thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.

1. Nameplate: At least 0.0625-inch-thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.02 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. 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.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.03 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

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

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

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Acceptance Testing:
      a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
      b. Test continuity of each circuit.
   2. Test ground-fault protection of equipment for service equipment per NFPA 70.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   5. Perform the following infrared scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
D. Switchboard will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

3.07 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories**,** and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

SECTION 26 2416 - PANELBOARDS

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:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Load centers.
   4. Electronic-grade panelboards.

1.03 DEFINITIONS

A. ATS: Acceptance testing specification.
B. GFCI: Ground-fault circuit interrupter.
C. GFEP: Ground-fault equipment protection.
D. HID: High-intensity discharge.
E. MCCB: Molded-case circuit breaker.
F. SPD: Surge protective device.
G. VPR: Voltage protection rating.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.
B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified by Division 01,include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.08 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding minus 22 deg. F to plus 104 deg. F.
      b. Altitude: Not exceeding this project site elevation in feet.
B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Architect, Construction Manager, and Owner no fewer than 14 days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
   3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
   1. Panelboard Warranty Period: 24 months from date of Substantial Completion.
B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
   1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 0548.16 "Seismic Controls for Electrical Systems."
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Comply with NEMA PB 1.
E. Comply with NFPA 70.
F. Enclosures: Flush and Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.

c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X.

d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Height: 84 inches maximum.

3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.

4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware. Both doors will be keyed.

5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.

7. Finishes:

a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Same finish as panels and trim.

c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Convertible between top and bottom.

2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.

b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.

3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Sub feed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting

and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
   1. Percentage of Future Space Capacity: 20 percent.

L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
   1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A RMS symmetrical.
   2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A RMS symmetrical.

M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
   1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A RMS symmetrical.
   2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A RMS symmetrical.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.03 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Square D
   2. Eaton.
   3. General Electric Company; GE Energy Management - Electrical Distribution.
   4. SIEMENS Industry, Inc.; Energy Management Division.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only as indicated on plans.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
   2. External Control-Power Source: 24-V control circuit.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company; GE Energy Management - Electrical Distribution.
   3. SIEMENS Industry, Inc.; Energy Management Division.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers:
      a. Inverse time-current element for low-level overloads.
      b. Instantaneous magnetic trip element for short circuits.

c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.

e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.

f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

g. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 0913 "Electrical Power Monitoring and Control."

h. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

i. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.

k. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.

l. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.

m. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

n. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.

o. Multipole units enclosed in a factory assembled to operate as a single unit.

p. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

q. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 26 2813 "Fuses."

2. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.

b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.

c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

2.05 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim **90 inches** above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

P. Mount spare fuse cabinet in accessible location.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems" identifying source of remote circuit.

3.04 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. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:
        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.06 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 26 2726 - WIRING DEVICES

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:
   1. Straight-blade convenience, hospital-grade, isolated-ground, and tamper-resistant receptacles.
   2. USB charger devices.
   3. GFCI receptacles.
   4. SPD receptacles.
   5. Hazardous (classified) location receptacles.
   6. Twist-locking receptacles.
   7. Pendant cord-connector devices.
   8. Cord and plug sets.
   9. Toggle switches.
   10. Decorator-style convenience.
   11. Wall switch sensor light switches with dual technology sensors.
   12. Wall switch sensor light switches with passive infrared sensors.
   13. Wall switch sensor light switches with ultrasonic sensors.
   14. Digital timer light switches.
   15. Residential devices.
   16. Wall-box dimmers.
   17. Wall plates.
   18. Floor service outlets.
   19. Poke-through assemblies.
   20. Prefabricated multi-outlet assemblies.
   21. Service poles.

1.03 DEFINITIONS

A. Abbreviations of Manufacturers' Names:
   1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
   2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
   3. Leviton: Leviton Mfg. Company, Inc.
   4. Pass & Seymour: Pass& Seymour/Legrand.
B. BAS: Building automation system.
C. EMI: Electromagnetic interference.
D. GFCI: Ground-fault circuit interrupter.
E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
F. RFI: Radio-frequency interference.
G. SPD: Surge protective device.
H. UTP: Unshielded twisted pair.ACTION SUBMITTALS
I. Product Data: For each type of product.
J. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
K. Samples: One for each type of device and wall plate specified, in each color specified.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.06 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 contents.
   1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
   2. Poke-Through, Fire-Rated Closure Plugs: One for every 10 floor service outlets installed, but no fewer than two.

3. SPD Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

PART 2 PRODUCTS

2.01 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.02 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.

B. Tamper-Resistant Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.

c. Leviton Manufacturing Co., Inc.

2. Description: Labeled and complying with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.03 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. USB Receptacles: Single, Type A.
4. Line Voltage Receptacles: Single, two pole, three wire, and self-grounding.

2.04 GFCI RECEPTACLES

A. General Description:

1. 125 V, 20 A, straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Hubbell Incorporated; Wiring Device-Kellems.

2.05 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. Eaton (Arrow Hart).
        b. Hubbell Incorporated; Wiring Device-Kellems.
        c. Leviton Manufacturing Co., Inc.

2.06 CORD AND PLUG SETS

A. Description:
    1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
    2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
    3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.07 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
B. Switches, 120/277 V, 20 A:
    1. Single Pole:
        a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
            1) Eaton (Arrow Hart).
            2) Hubbell Incorporated; Wiring Device-Kellems.
            3) Leviton Manufacturing Co., Inc.

2. Two Pole:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Eaton (Arrow Hart).
        2) Hubbell Incorporated; Wiring Device-Kellems.
        3) Leviton Manufacturing Co., Inc.
3. Three Way:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Eaton (Arrow Hart).
        2) Hubbell Incorporated; Wiring Device-Kellems.
        3) Leviton Manufacturing Co., Inc.
4. Four Way:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Eaton (Arrow Hart).
        2) Hubbell Incorporated; Wiring Device-Kellems.
        3) Leviton Manufacturing Co., Inc.

C. Pilot-Light Switches: 120/277 V, 20 A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

D. Key-Operated Switches: 120/277 V, 20 A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.

2.08 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.

B. Tamper-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.

2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

C. Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section, when installed in wet and damp locations.

D. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

E. GFCI, Tamper-Resistant and Weather-Resistant Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
2. Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwelling Units" Section.

F. Toggle Switches: Square Face, 120/277 V, 15 A; comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.

G. Lighted Toggle Switches: Square Face, 120 V, 15 A; comply with NEMA WD 1 and UL 20.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.
2. Description: With LED-lighted handle, illuminated when switch is off.

2.09 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Wiremold, Legrand

B. Description:
1. Two-piece surface metal raceway, with factory-wired multi-outlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.

D. Multi-outlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: As indicated on plans.
3. Wiring: No. 12 AWG solid, Type THHN copper, multiple circuit, connecting alternating receptacles.

2.11 FINISHES

A. Device Color:
   1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
   2. Wiring Devices Connected to Stand-by Power System: Red.
   3. SPD Devices: Blue.
B. Wall Plate Color: For plastic covers, match device color.

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
B. Coordination with Other Trades:
   1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.
C. Conductors:
   1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pig tailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:
1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.03 IDENTIFICATION

A. Comply with Section 26 0553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with **black**-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.04 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

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

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION

SECTION 26 2813 - FUSES

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:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Control circuits.
      b. Motor-control centers.
      c. Panelboards.
      d. Switchboards.
      e. Enclosed controllers.
      f. Enclosed switches.
   2. Spare-fuse cabinets.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   3. Current-limitation curves for fuses with current-limiting characteristics.

4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software.
4. Coordination charts and tables and related data.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.06 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F temperature or more than 100 deg F temperature>, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bussmann, an Eaton business.

2. Edison; a brand of Bussmann by Eaton.
3. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
1. Type RK-1: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
7. Type T: 250-V, zero- to 1200-A, 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.03 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
1. Size: Adequate for storage of spare fuses specified with **15** percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: **Class** L, fast acting, Class RK1, fast acting, lass RK1, time delay.
2. Motor Branch Circuits: Class RK1, Class CC, motor duty, time delay.
3. Large Motor Branch (601-4000 A): Class L, time delay.
4. Power Electronics Circuits: Class T, fast acting.
5. Other Branch Circuits: Class RK1, time delay, Class RK5, time delay, Class J, fast acting, Class J, time delay, Class CC, fast acting.
6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.03 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

B. Shop Drawings: For enclosed switches and circuit breakers.
1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
1. In addition to items specified by Division 01, include the following:
a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Fuse Pullers: Two for each size and type.

1.08 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.09 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: One year from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according **to** ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NFPA 70.

2.03 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB Inc.
   2. Eaton.
   3. General Electric Company.
   4. SIEMENS Industry, Inc.; Energy Management Division.

B. Type HD, Heavy Duty:
   1. Single throw.
   2. Three pole.
   3. 600-V ac.
   4. 1200 A and smaller.
   5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
   6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.04 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   3. SIEMENS Industry, Inc.; Energy Management Division.

B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.05 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   3. NOARK Electric North America.
   4. SIEMENS Industry, Inc.; Energy Management Division.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be rated as indicated on the Drawings. Circuit breaker/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal 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.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay

settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 26 0913 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO and NC contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

2.06 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   3. NOARK Electric North America.
   4. SIEMENS Industry, Inc.; Energy Management Division.

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:
   1. Standard frame sizes and number of poles.

2. Lugs:
    a. Compression type, suitable for number, size, trip ratings, and conductor material.
    b. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below rating in NFPA 70.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO and NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

2.07 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock

mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.02 PREPARATION

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

1. Notify Architect, Construction Manager, Owner no fewer than 14 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, Owner's written permission.
4. Comply with NFPA 70E.

3.03 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.04 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

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

E. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, grounding, and clearances.
    c. Verify that the unit is clean.
    d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
    e. Verify that fuse sizes and types match the Specifications and Drawings.

f. Verify that each fuse has adequate mechanical support and contact integrity.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.

i. Verify correct phase barrier installation.

j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Measure contact resistance across each switchblade fuse holder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of

insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

F. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.

f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar

connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.

i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports.

1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.

3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study.

END OF SECTION

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:

1. Section 26 2413 "Switchboards" for factory-installed SPDs.
2. Section 26 2416 "Panelboards" for factory-installed SPDs.

1.03 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Ten** years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.02 SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

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

1. ABB USA.
2. Advanced Protection Technologies Inc. (APT).
3. ALLTEC.
4. Atlantic Scientific.
5. Current Technology Inc.

6. Danaher Power Solutions.
7. Eaton.
8. General Electric Company.
9. Intermatic, Inc.
10. LEA International.
11. Leviton Manufacturing Co., Inc.
12. Liebert; a brand of Emerson Electric Co.
13. Northern Technologies, Inc.
14. Raycap, Inc.

B. SPDs: Comply with UL 1449, Type 2.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2

1. SPDs with the following features and accessories:
    a. Integral disconnect switch.
    b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
    c. Indicator light display for protection status.
    d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
    e. Surge counter.

D. Comply with UL 1283.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

G. SCCR: Equal or exceed 250 kA.

H. Inominal Rating: 20 kA.

2.03 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB USA.
   2. Advanced Protection Technologies Inc. (APT).
   3. ALLTEC.
   4. Atlantic Scientific.
   5. Current Technology Inc.
   6. Danaher Power Solutions.
   7. Eaton.
   8. General Electric Company.
   9. Intermatic, Inc.
   10. LEA International.
   11. Leviton Manufacturing Co., Inc.
   12. Liebert; a brand of Emerson Electric Co.
   13. Northern Technologies, Inc.
   14. Raycap, Inc.

B. SPDs: Comply with UL 1449, Type 2.
   1. Include LED indicator lights for power and protection status.
   2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than **100 kA**. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Comply with UL 1283.

2.04 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.
B. Outdoor Enclosures: NEMA 250, Type 3R.

2.05 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.
B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
D. Use crimped connectors and splices only. Wire nuts are unacceptable.
E. Wiring:
    1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
    2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.03 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 5119 - LED INTERIOR LIGHTING

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:
   1. Interior solid-state luminaires that use LED technology.
   2. Lighting fixture supports.

B. Related Requirements:
   1. Section 26 0923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.

5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79, IES LM-80 and IESNA TM-21-11.
    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
7. Include lighting calculations for each space using standard reflectances and working plane height of 30” AFF for comparison to Basis of Design.

B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.07 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
C. Provide luminaires from a single manufacturer for each luminaire type.
D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.09 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.02 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. CRI of minimum 80. CCT of 3500K.

F. Rated lamp life of 50,000 hours.

G. LEDs dimmable from 100 percent to 0 percent of maximum light output.

2.03 Internal LINEAR driver

A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall have a slim profile with height ≤ 1 in and width ≤ 1.2 in.
3. Driver shall be provided with integral color-coded connectors.

B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of +/- 10% (voltage) with no damage to the Driver.
2. Driver output shall be regulated to +/- 5% across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of -20C (-4F).

8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency >100Hz.
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.
14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory
1. Driver shall not contain any Polychlorinated Biphenyl (PCB).
2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other
1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150µA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.

E. Nominal Operating Voltage: Multi tap drivers will provide 120Vac and/or 277Vac.

2.04 INTERNAL DOWNLIGHT DRIVER

A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall be in a compact enclosure with integrated studs so that it can be mounted on the outside or a junction box, without the need of an additional enclosure.
3. Driver shall be provided with integral color-coded connectors.

B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of +/- 10% (voltage) with no damage to the Driver.
2. Driver output shall be regulated to +/- 5% across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of -20C (-4F).
8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency >100Hz.
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.
14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory

1. Driver shall not contain any Polychlorinated Biphenyl (PCB).

2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other

1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C.
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150μA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.
5. Nominal Operating Voltage: Multi tap drivers will provide 120Vac and/or 277Vac

2.05 DOWNLIGHT

A. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt. Unless noted otherwise on luminaires schedule.

B. Universal mounting bracket.

C. Integral junction box with conduit fittings.

2.06 STRIP LIGHT

A. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Integral junction box with conduit fittings.

2.07 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit new LEDs without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during replacement and when secured in operating position.

C. Housings:

1. Will be as called for in the Luminaire Schedule for this project. This will include housing and heat sink.
2. Powder-coat and painted finish. Unless otherwise noted in the luminaire schedule for this project.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI for all luminaires.

2.08 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.09 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and replacement of LEDs.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall as means of attachment.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Recessed-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
   3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

H. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

D. Adjusting

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
   1. During adjustment visits, inspect all luminaires. Replace drivers or luminaires that are defective.
   2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
   3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 26 5219 - EMERGENCY AND EXIT LIGHTING

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:
   1. Emergency lighting units.
   2. Exit signs.
   3. Luminaire supports.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
D. Fixture: See "Luminaire" Paragraph.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
   1. Include data on features, accessories, and finishes.
   2. Include physical description of the unit and dimensions.
   3. Battery and charger for light units.
   4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs shall be certified by manufacturer.

b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each product and for each color and texture specified.

D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

a. Other luminaires.

b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.
C. Product Certificates: For each type of luminaire.
D. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Provide seismic qualification certificate for each piece of equipment.
E. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.
F. Sample Warranty: For manufacturer's special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.07 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. LED boards: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and LEDs shall be labeled vibration and shock resistant.
   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.02 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
C. Comply with NFPA 70 and NFPA 101.
D. Comply with NEMA LE 4 for recessed luminaires.
E. Comply with UL 1598 for fluorescent luminaires.
F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.
G. Bulb Shape: Complying with ANSI C79.1.
H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with LED Driver.
   1. Emergency Connection: Operate one LED board continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.

2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding this project site in feet.
4. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
5. Battery: Sealed, maintenance-free, nickel-cadmium type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.03 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility and lettering size, comply with authorities having jurisdiction.

2.04 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:
   1. Smooth operating, free of light leakage under operating conditions.
   2. Designed to permit relamping without use of tools.
   3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
   1. Diffuse glass.
   2. Glass: Annealed crystal glass unless otherwise indicated.
   3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:
   1. Extruded aluminum housing and heat sink.
   2. Clear anodized finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.05 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.06 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.02 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20-gage backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
   3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
   4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
   3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

D. Spare Exit signs:
   1. Provide 10% spare exit of the total installed in this facility.
   2. These spare units will be utilized and installed per AHJ final inspection of egress paths. Should AHJ request additional exit signs these spare will be installed as directed.
   3. Owner will bear no cost for these spare and any installation due to AHJ requirement to add additional exit signs.

4. Any exit signs not used will be given to owner.

3.05 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.06 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
    a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

END OF SECTION

SECTION 26 5619 – LED EXTERIOR LIGHTING

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:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire supports.
   3. Luminaire-mounted photoelectric relays.

B. Related Requirements:
   1. Division 26, Section 26 5119, LED Interior Lighting, for interior Luminaires, and accessories.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Luminaire: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including LEDs, Drivers, Reflector, and Housing.

1.04 ACTION 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 luminaire.
   1. Arrange in order of luminaire schedule designation.
   2. Include data on features, accessories, and finishes.

3. Include physical description and dimensions of luminaire.
4. LEDs, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for LEDs and accessories identical to those indicated for the luminaire as applied in this Project; IES LM-79 and IES LM-80
    a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer
6. Wiring diagrams for power, control, and signal wiring. Wiring diagrams for control system showing both factory-installed and field-installed wiring for specific system of this Project, and differentiating between factory-installed and field-installed wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
9. Luminaire, LEDs, Drivers, Poles, and accessories. Include data on features, Poles, accessories, finishes, and the following:
    a. Outline drawings indicating dimensions and principal features of Luminaire and Poles.
    b. Electrical Ratings and Photometric Data: Certified results of independent laboratory tests for Luminaires and LEDs.
10. Wind Resistance Calculations: Certified by a registered professional engineer
11. Anchor-Bolt Templates: Keyed to specific poles and certified by manufacturer.
12. Field test reports indicating and interpreting test results specified in Part 3 of this section.
13. Maintenance data for products to include in the operation and maintenance manual specified in Division 1.
14. Product certificates signed by manufacturers of lighting units certifying that their products comply with specified requirements.

C. Include lighting calculations for each space using the following reflectance's, 75,45,20, and working plane height of 30" AFF for comparison to Basis of Design

D. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

E. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

F. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.05 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. Luminaires.
2. Structural members to which luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of the following:
   1. Luminaire.
   2. Photoelectric relay.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Source quality-control reports.

G. Sample warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
   1. Provide a list of all LED types used on Project. Use ANSI and manufacturers' codes.

1.07 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. LEDs: One for every 50 of each type and rating installed. Furnish at least one of each type.
   2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Diffusers and Lenses: One for every 50 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: One for every 50 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Listing and Labeling: Provide Luminaires and accessories specified in this Section that are listed and labeled for their indicated use and installation conditions on Project.

1. Special Listing and Labeling: Provide Luminaires for use underwater that are specifically listed and labeled for such use. Provide Luminaires for use in hazardous (classified) locations that are listed and labeled for the specific hazard.
2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
3. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.

E. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

F. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

G. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING

A. General: Store poles on decay-resistant treated skids at least 12 inches above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation

B. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

C. Metal Poles: Retain factory-applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. General Warranty: The warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents

B. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
    a. Structural failures, including luminaire support components.
    b. Faulty operation of luminaires and accessories.
    c. Deterioration of metals, metal finishes, and other materials beyond normal weathering. Warranty against perforation or erosion of finish due to weathering.
    d. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation
2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Products: Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to SCE/SEI 7.

B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.03 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location where indicated in Luminaire schedule.

E. Bulb shape complying with ANSI C79.1.

F. CRI of minimum 80.

G. CCT of 4100 K or as indicated in the luminaire schedule.

H. L70 LED life of 50,000 minimum hours.

I. Internal driver.

J. Nominal Operating Voltage: Multi-Tap Drivers - 120 V or 277 V.

K. In-line Fusing: Separate in-line fuse for each luminaire.

L. LED Rating: LED marked for outdoor use.

M. Source Limitations: Obtain luminaires from single source from a single manufacturer.

N. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

O. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed Luminaires.

P. Exposed Hardware Material: Stainless steel.

Q. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

R. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in Luminaire doors.

2.04 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Stainless steel. 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 re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
    a. "USE ONLY" and include specific lamp type.
    b. Lamp diameter, shape, size, wattage and coating.
    c. CCT and CRI for all luminaires.

2.05 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are not acceptable. Arm, Bracket, and Tenon Mount will match poles' finish.

B. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's full range.

C. Mountings, Fastenings, and Appurtenances: Corrosion-resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.

2.06 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Pole-Mounted Luminaires: Conform to AASHTO LTS-3.

C. Wind-load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus Luminaires indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 Mi./Hr. with a gust factor of 1.3.

D. Poles: Provide factory installed vibration dampers.

E. Pole Shafts: Round, straight.

F. Pole Bases: Anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.

G. Poles: Steel tubing conforming to ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psi. Poles are 1-piece construction up to 40 feet in length and have access handhole in wall.

H. Metal Pole Grounding Provisions: Welded 1/2-inch threaded lug, accessible through handhole.

I. Steel Mast Arms: Fabricated from 2-inch NPS (DN50) black steel pipe, continuously welded to pole attachment plate with span and rise as indicated.

J. Metal Pole Brackets: Designed to match pole metal. Provide cantilever brackets without underbrace, in sizes and styles indicated, with straight tubular end section to accommodate Luminaire.

K. Pole-Top Tenons: Fabricated to support Luminaire or Luminaires and brackets indicated and securely fastened to pole top.

L. Concrete for Pole Foundations: Comply with structural details for the base required for Poles on this project. Details in this division drawings indicate electrical information and do not call out any structural information.

1. Construct according to Division 3, Section 03 3000, Cast-in-Place Concrete.
2. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
3. Finish: Trowel and rub smooth parts exposed to view

M. Embedded Poles: Set poles to indicated depth, but not less than 1/6 of pole length below finish grade. Dig holes large enough to permit use of tampers the full depth of hole. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

N. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.

O. Luminaire Attachment: Fasten to indicated structural supports.

P. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.

Q. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall.

F. Wiring Method: Install cables in raceways. Conceal raceways and cables.

G. Set Luminaires securely according to manufacturer's written instructions and approved Shop Drawings. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

H. Coordinate layout and installation of luminaires with other construction.

I. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution. Adjust luminaires that require field adjustment or aiming once luminaire is in place .

J. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 0533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

K. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs

3.04 GROUNDING

A. Ground fixtures and metal poles according to Division 26, Section 26 0526, Grounding and Bonding for Electrical Systems.

1. Poles: Install 10-foot driven ground rod at each pole.
2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor, minimum

3.05 CORROSION PREVENTION

A. Steel Conduits: Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.07 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results. Use photometers with calibration referenced to National Institute of Standards and Technology (NIST) standards.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After installing luminaires, control system, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Verify operation of photoelectric controls.
   3. Check for intensity of illumination.
   4. Check for uniformity of illumination.
   5. Check for excessively noisy Driver.

E. Illumination Tests:
   1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
      a. IES LM-5.
      b. IES LM-50.
      c. IES LM-52.
      d. IES LM-64.
      e. IES LM-72.

F. Luminaire will be considered defective if it does not pass tests and inspections. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until all units operate properly

G. 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.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

3.09 ADJUSTING

A. Clean units after installation. Use methods and materials recommended by manufacturer. Adjust aimable fixtures to provide required light intensities.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied

conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace LEDs or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

3.10 EXTERIOR LIGHTING FIXTURE SCHEDULE

A. The luminaire schedule located in the construction drawings describes each type of luminaire for the project. Manufacturer’s catalog numbers are given for convenience. Where discrepancies occur between catalog numbers and the descriptive information, the descriptive information shall take precedence. Some required features, options, accessory equipment or special order requirements may not be included in the catalog number.

END OF SECTION

SECTION 28 3100 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. Contractor is responsible for providing and installing a complete "turn-key" Fire Alarm system that meets or exceeds the specifications listed below.

B. This Section includes fire alarm systems, including manual stations, detectors, signal equipment, controls, and devices. Note that this is a performance based specification. Equipment/device quantities and locations indicated are diagrammatic. Design of the fire alarm system, including device placements, selection and quantities, shall be by a NICET level III designer in accordance with the requirements of the New Mexico State and KAFB Fire Marshall's Office. The design shall be approved by the New Mexico State Fire Marshall's Office. Refer to additional submission requirements below.

1.03 DEFINITION

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

1.04 SYSTEM DESCRIPTION

A. General: Zoned, noncoded, addressable, microprocessor-based fire-detection and alarm system with manual and automatic alarm initiation, analog addressable smoke detectors, and automatic alarm verification for alarms initiated by certain smoke detector zones as indicated, voice notification.

B. Signal Transmission: Multiplex signal transmission dedicated to fire alarm service only.

C. Audible Alarm Indication: By sounding through speakers.

D. Visual Alarm Indication: By ADA compliant xenon-strobe-type units.

E. System connections for alarm-initiating and alarm-indicating circuits. Class B wiring.

1.05 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 system component specified including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include list of materials and Nationally Recognized Testing Laboratory (NRTL)-listing data.

C. Shop Drawings showing details of graphic annunciator.

D. Wiring Diagrams from manufacturer differentiating clearly between factory- and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Make all diagrams specific to this Project and distinguish between field and factory wiring.

E. Floor Plans: Indicate final device locations and routings of raceway connections.

F. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

1. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
2. Show field wiring required for HVAC unit shutdown on alarm.
3. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
4. Locate detectors according to manufacturer's written recommendations.

G. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.

2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

H. Sound pressure level calculations and intelligibility calculations for all spaces in the building.

I. Include input/output matrix.

J. Device Address List: Coordinate with final system programming.

K. System operation description covering this specific Project, including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are unacceptable. Complete riser/1-line diagram indicating all devices and interconnections.

L. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

M. Operating instructions for mounting at the FACP.

N. Product certificates signed by manufacturers of fire alarm system components certifying that their products comply with specified requirements.

O. Maintenance data for fire alarm systems to include in the operation and maintenance manual specified in Division 1. Include data for each type of product, including all features and operating sequences, both automatic and manual. Include recommendations for spare parts to be stocked at the site. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.

P. Submission to Authorities Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authorities having jurisdiction. Shop drawing submission to the New Mexico State Fire Marshall shall meet all requirements stated in the New Mexico State Fire Marshall’s Office Plans Review Submittal Requirements and Information publication. Include Professional Engineer’s seal, and design by a NICET Level III technician as part of the preparation and submission of the shop drawings. Upon receipt of comments from the authorities having jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval. Do not proceed with any work prior to approval from the New Mexico State Fire Marshall’s Office.

Q. Record of field tests of system.

R. Battery and voltage drop calculations.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced factory-authorized Installer to perform work of this Section.

B. Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility of system components.

C. Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the authorities having jurisdiction.

D. Comply with NFPA 70.

E. Comply with NFPA 72.

F. Listing and Labeling: Provide fire alarm systems and components specified in this Section that are listed and labeled by Factory Mutual.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed, are packaged with protective covering for storage, and are identified with labels clearly describing contents.

1. Glass Rods for Manual Stations: Quantity equal to 15 percent of the number of manual stations installed; minimum of 6 rods.
2. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of the number of units installed, but not less than 1.
3. Lamps for Strobe Units: Quantity equal to 10 percent of the number of units installed, but not less than 1.
4. Smoke Detectors, and Fire Detectors: Quantity equal to 10 percent of the number of units of each type installed, but not less than 1 of each type.
5. Speaker, speaker\strobe and strobe units: Quantity equal to 10 percent of the number of units of each type installed, but not less than 5 of each type.
6. Detector Bases: Quantity equal to 2 percent of the number of units of each type installed, but not less than 1 of each type.

1.08 ADDITIONAL WORK

A. In addition to quantities indicated on floor plans, include in the work provide and installing (5) five additional of each of the following: smoke detectors, pull stations, duct smoke detectors, control relay modules, audible/strobe units, strobe only, speaker/strobe and speaker only units. These units are to be installed at direction of the Architect in field during construction. Allow for complete installation including conduit, wire and system capacity.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Include the following system functions and operating features plus those additional functions and features required by the authorities having jurisdiction:
   1. Priority of Signals: Accomplish automatic response functions by the first zone initiated. Alarm functions resulting from initiation by the first zone are not altered by subsequent alarms. The highest priority is an alarm signal. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even though the lower-priority condition occurred first. Annunciate all alarm signals regardless of priority or order received.
   2. Noninterfering: Zone, power, wire, and supervise the system so a signal on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. Systems that require batteries or battery back-up for the programming function are unacceptable.
   3. Fire Alarm Control Panel (FACP) Response: The manual or automatic operation of an alarm-initiating or supervisory-operating device causes the FACP to transmit an appropriate signal including the following:

a. General alarm.
b. Fire-suppression system operation alarm.
c. Smoke or heat detector alarm.
d. Valve tamper supervisory.
e. System trouble.
f. Fan shutdown.

4. Transmission to Remote Central Station: Automatically route alarm, supervisory, and trouble signals to a remote central station service.
5. Silencing at the FACP: Switches provide capability for acknowledgment of alarm, supervisory, trouble, and other specified signals at the FACP; and capability to silence the local audible signal and light a light-emitting diode (LED). Subsequent zone alarms cause the audible signal to sound again until silenced by switch operation. Restoring alarm, supervisory and trouble conditions to normal extinguishes the associated LED and causes the audible signal to sound again until restoration is acknowledged by switch operation.
6. Loss of primary power at the FACP sounds a trouble signal at the FACP and the annunciator. An emergency power light is illuminated at both locations when the system is operating on an alternate power supply.
7. Annunciation: Manual and automatic operation of alarm- and supervisory-initiating devices is annunciated both on the FACP and on the annunciator, indicating location and type of device.
8. FACP Alphanumeric Display: Displays plain-English-language descriptions and addresses of initiating devices, alarms, trouble signals, supervisory signals, monitoring actions, system and component status, and system commands.
9. General Alarm: A system general alarm includes the following:
    a. Indicating the general alarm condition at the FACP and the annunciator.
    b. Identifying the device that is the source of the alarm (or its zone) at the FACP and the annunciator.
    c. Initiating voice alarms and visible alarm signals throughout the building.
    d. Stopping supply and return fans serving zone where alarm is initiated.
    e. Closing smoke dampers on system serving zone where alarm is initiated.
    f. Unlocking designated doors.

g. Recording the event on the system.

h. Initiating transmission of alarm signal to remote central station.

10. Manual station alarm operation initiates a general alarm.

11. Water-flow alarm switch operation:

a. Initiates a general alarm.

b. Causes flashing of the device location-indicating lamp for the device that has operated.

12. Smoke detection initiates a general alarm.

13. Sprinkler valve tamper switch operation causes or initiates the following:

a. A supervisory, audible, and visible "valve tamper" signal indication at the FACP and the annunciator.

b. The location-indicating light to flash for the device that has operated.

c. A printed record of the event on the system printer.

d. Transmission of supervisory signal to remote central station.

14. Low-air-pressure switch operation on a preaction sprinkler system causes or initiates the following:

a. A supervisory, audible, and visible "sprinkler trouble" signal indication at the FACP and the annunciator.

b. The location-indicating light to flash for the device that has operated.

c. A printed record of the event on the system printer.

d. Transmission of trouble signal to remote central station.

15. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. The same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity adjustment schedule changes are recorded by the system printer.

16. Elevator Recall:

a. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

1) Elevator lobby detectors except the lobby detector on the designated floor.

2) Smoke detector in elevator machine room.

3) Smoke detectors in elevator hoistway.

b. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.

c. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

1) Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

17. 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.

B. Recording of Events: Print a record for all alarm, supervisory, and trouble events on the system printer. Printouts are by zone, device, and function. When the FACP receives a signal, the alarm, supervisory, and trouble conditions are printed. The printout includes the type of signal (alarm, supervisory, or trouble) the zone identification, date, and the time of the occurrence. The printout differentiates alarm signals from all other printed indications. When the system is reset, this event is also printed, including the same information for device, location, date, and time. A command initiates the printout of a list of existing alarm, supervisory, and trouble conditions in the system.

1. Permissible Signal Time Elapse: The maximum permissible elapsed time between the actuation of any fire alarm or fire-detection system alarm-initiating device and its indication at the FACP is two (2) seconds.

2. Independent System Monitoring: Supervise each independent smoke- or heat-detection system and duct detector system for both normal operation and trouble.

3. Circuit Supervision: Indicate circuit faults by both a zone and a trouble signal at the FACP. Provide a distinctive indicating audible tone and LED-indicating light. The maximum permissible elapsed time between the occurrence of the trouble condition and its indication at the FACP is 200 seconds.

2.03 ADDRESSABLE DEVICES

A. Alarm-Initiating Devices: Classified as addressable devices according to NFPA 72.

1. Communication Transmitter and Receiver: Integral to device. Provides each device with a unique identification and capability for status reporting to the FACP.

2.04 MANUAL PULL STATIONS

A. Description: Double-action type, fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.

1. Break-Glass Feature: Stations requiring the breaking of a glass panel are unacceptable. Stations requiring the breaking of a concealed glass rod are acceptable.
2. Station Reset: Key or wrench operated, double pole, double throw, switch rated for the voltage and current at which it operates. Stations have screw terminals for connections.

2.05 SMOKE DETECTORS

A. General: Comply with UL 268. Include the following features:

1. Factory Nameplate: Serial number and type identification.
2. Operating Voltage: 24-V dc, nominal.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Plug-in Arrangement: Detector and associated encapsulated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. The plug connection requires no springs for secure mounting and contact maintenance. Terminals in the fixed base accept building wiring.
5. Integral Visual Indicating Light: Connect to indicate detector has operated.
6. Remote Controllability: Individually monitor detectors at the FACP for calibration, sensitivity, and alarm condition, and individually adjust for sensitivity from the FACP.

B. Photoelectric Smoke Detectors: Include the following features:

1. Detector Sensitivity: Between 2.5- and 3.5-percent-per-foot (0.008- and 0.011-percent-per-mm) smoke obscuration when tested according to UL 268.
2. Sensor: An infrared detector light source with matching silicon-cell receiver.

C. Duct Smoke Detector: Photoelectric type.

1. Sampling Tube: Design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied.
2. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

D. Multicriteria Detectors

1. Mounting: [Adapter plate for outlet box mounting] [Twist-lock base interchangeable with smoke-detector bases].

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
3. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.
4. Test button tests all sensors in the detector.
5. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    a. Primary status.
    b. Device type.
    c. Present sensitivity selected.
    d. Sensor range (normal, dirty, etc.).
6. Sensors: The detector shall be comprised of multi sensing elements including a smoke sensor, an infrared sensor, and a heat sensor.
    a. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
    b. Heat sensor shall be as described in "Heat Detectors" Article.
    c. Each sensor shall be separately listed according to requirements for its detector type.

2.06 OTHER DETECTORS

A. Thermal Detector: Combination fixed-temperature and rate-of-rise unit with mounting plate arranged for outlet box mounting; 135 deg F (57 deg C) fixed-temperature setting, except as indicated.

2.07 ALARM-INDICATING DEVICES

A. General: Equip alarm-indicating devices for mounting as indicated. Provide terminal blocks for system connections.

B. Visual Alarm Devices: Xenon strobe lights with clear or nominal white polycarbonate lens. Mount lenses on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch (25-mm) high letters on the lens. UL Listed to Standard 1971.
    1. Devices have a minimum light output of 115 candela.

2. Strobe Leads: Factory connected to screw terminals.
3. Combination devices consist of factory-combined, audible and visual alarm units in a single mounting assembly.

C. Remote Alarm Indicator: LED type, mounted flush in a single gang wall plate.
1. Connected to indicate the alarm operation of a single detector or other device.
2. Legend: "Alarm."

D. Voice/Tone Speakers: Comply with UL 1480.
1. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.
2. High-Range Speaker Units: Rated 2 to 15 W.
3. Low-Range Speaker Units: Rated 1 to 2 W.
4. Speaker Mounting: Flush, semirecessed, surface, or surface-mounted bidirectional as indicated.

2.08 REMOTE DEVICE LOCATION-INDICATING LIGHTS AND IDENTIFICATION PLATES

A. Description: An LED-indicating light in the vicinity of each concealed device to denote the associated device is in an abnormal or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, the room where the device is located. Provide for the following devices:
1. Sprinkler water-flow switch and valve tamper switch. Identify the room or the protected spaces downstream from the water-flow switch.
2. All detectors.

2.09 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting and furnished by the door hardware company with 120V power requirements. Provide addressable relay to control (disconnect) holder 120V power source.

2.10 CENTRAL FIRE ALARM CONTROL PANEL (FACP)

A. General: Comply with UL 864.

B. Cabinet: Lockable steel enclosure. Arrange panel so all operations required for testing or for

normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control panel, provide exactly matching modular unit enclosures. Accommodate all components and allow ample gutter space for interconnection of panels and field wiring. Identify each enclosure by an engraved, red, laminated, phenolic-resin nameplate. Lettering on the enclosure's nameplate shall not be less than 1 inch (25 mm) high. Identify individual components and modules within the cabinets with permanent labels.

C. Systems: Alarm and supervisory systems are separate and independent in the FACP. The alarm-initiating zone boards in the FACP consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.

D. Control Modules: Types and capacities required to perform all functions of the fire alarm systems. Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.

E. Zones: Provide for all alarm and supervisory zones indicated.

F. Resetting: Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm or trouble condition still exists.

G. Alphanumeric Display and System Controls: Arrange to provide the basic interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control. A display with a minimum of 32 characters shows alarm, supervisory and component status messages and indicates control commands to be entered into the system for control of smoke detector sensitivity and other parameters. Arrange keypad for use in entering and executing control commands.

H. Voice Alarm: An emergency communication system, integral with the FACP, includes central voice alarm system components complete with microphones, preamplifiers, amplifiers, and tone generators. Features include the following:

1. Amplifiers comply with UL 1711.
2. Two alarm channels permit simultaneous transmission of different announcements to different zones or floors automatically or by using the central control microphone. All announcements are made over dedicated, supervised communication lines.
3. Status annunciator indicates the status of the various voice alarm speaker zones and the status of firefighter telephone 2-way communication zones.

I. Instructions: Printed or typewritten instruction card mounted behind a lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a location observable from the FACP. Include interpretation and appropriate response for displays and signals, and briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.11 SYSTEM PRINTER

A. General: Printer is dot-matrix type, listed and labeled as an integral part of the fire alarm system.

2.12 EMERGENCY POWER SUPPLY

A. General: Components include nickel-cadmium-type battery, charger, and an automatic transfer switch. Battery nominal life expectancy is 20 years, minimum.

B. Battery capacity is adequate to operate the complete alarm system in normal or supervisory (nonalarm) mode for a period of 24 hours. At the end of this period, the battery has sufficient capacity to operate the system, including alarm-indicating devices in either alarm or supervisory mode, for a period of 15 minutes.

C. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.

D. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining the batteries at full charge. In the event batteries are fully discharged, the charger recharges them completely within 4 hours. Charger output is supervised as part of system power supply supervision.

E. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.13 WIRE

A. Wire: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.

2.14 UNIVERSAL DIGITAL ALARM COMMUNICATOR TRANSMITTER (UDACT)

A. Provide a UDACT at the FACP. Program, connect and configure to communicate with monitoring agency as instructed by Architect. UDACT shall be Notifier #UDACT or equal.

2.15 ADDRESSABLE INTERFACE DEVICE

A. General:
   1. Include address-setting means on the module.
   2. Store an internal identifying code for control panel use to identify the module type.
   3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
   1. Allow the control panel to switch the relay contacts on command.
   2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:
   1. Operate notification devices.
   2. Operate solenoids for use in sprinkler service.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Install system according to NFPA standards referenced in Parts 1 and 2 of this Section.

B. Fire Alarm Power Supply Disconnect: Paint red and label "FIRE ALARM." Provide with lockable handle or cover.

3.02 EQUIPMENT INSTALLATION

A. Manual Pull Stations: Mount semiflush in recessed back boxes with operating handles 48 inches (1220 mm) above the finished floor or lower as indicated.

B. Water-Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.

C. Smoke Detectors: Install ceiling-mounted detectors not less than 4 inches (100 mm) from a side wall to the near edge. Install detectors located on the wall at least 4 inches (100 mm), but not more than 12 inches (300 mm), below the ceiling. For exposed solid-joist construction, mount detectors on the bottom of the joists. On smooth ceilings, install detectors not over 30 feet (9 m) apart in any direction. Install detectors no closer than 60 inches (1520 mm) from air registers.

D. Audible Alarm-Indicating Devices: Install not less than 90 inches (2280 mm) above the finished floor nor less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille or as indicated. Combine audible and visual alarms at the same location into a single unit.

E. Visual Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and not more than 80 inches (2030 mm) above the finished floor and at least 6 inches (150 mm) below the ceiling.

F. Device Location-Indicating Lights: Locate in public space near the device they monitor.

G. FACP: Surface mount with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.03 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

B. All pathways are to be EMT.

C. All pathways are to be painted red enamel.

3.04 WIRING INSTALLATION

A. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceways, Boxes, and Cabinets." Conceal raceway except in unfinished spaces and as indicated.

B. Wiring within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

C. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

D. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and a different color code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visual alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

E. Wiring to Central-Station Transmitter: 1-inch (27) GRC between the FACP and the central-station transmitter connection as indicated. Install number of conductors and electrical supervision for connecting wiring as needed to suit central-station monitoring function. Final connections to terminals in central-station transmitter are made under another contract.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 26 Section "Electrical Identification."

3.06 GROUNDING

A. Ground cable shields and equipment according to system manufacturer's instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements of Division 26 Section "Grounding."

D. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.07 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

B. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of the witnesses to the preliminary tests.

D. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.

E. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72. Minimum required tests are as follows:

1. Verify the absence of unwanted voltages between circuit conductors and ground.
2. Test all conductors for short circuits using an insulation-testing device.
3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on the record drawings.
4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the

initiating and indicating devices. Observe proper signal transmission according to class of wiring used.

6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.
8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.

H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.08 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

3.09 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.11 DEMONSTRATION

A. Startup Services: Engage a factory-authorized service representative to provide startup service and to demonstrate and train Owner's maintenance personnel as specified below.

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of eight (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 seven (7) days advance notice.

3.12 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to 3 requested adjustment visits to the site for this purpose.

END OF SECTION

SECTION 31 10 00 | SITE CLEARING

PART1 GENERAL

1.0I SCOPE OF WORK

A. Furnish all labor, materials , equipment and incidentals necessary to perform all excavation work and grading; place and compact backfill and fill; and dispose of unsuitable , waste and surplus materials as shown on the Drawings or as directed by the OWNER, and as specified herein. The work shall include, but not necessarily be limited to; excavation for channel relocation, cap materials , and erosion control; all backfilling and fill; embankment and grading; disposal of waste and surplus materials; and all related work such as sheeting, bracing and pumping.

B. Furnish and install temporary excavation support systems, including sheeting, shoring and bracing, to insure the safety of personnel and protect adjacent structures, piping, etc. , in accordance with federal, state and local laws, regulations and requirements.

C. Temporary Erosion and Sediment Control is included in Section 603 of the New Mexico State Department of Transportation Standard Specifications for Highway and Bridge Construction, 20I9 edition, as may be amended.

1.02 SUBMJTTALS

A. Submit the proposed methods of construction, including excavation, excavation support systems designs, backfilling and filling, and compaction for the various portions of the Work. Excavation support system designs shall be prepared by a licensed professional ENGINEER, registered in the State of New Mexico, having a minimum of five years of professional experience in design and construction of excavation support systems. Review will be for information only. CONTRACTOR shall remain responsible for adequacy and safety of construction means, methods, and techniques.

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM D698 - Standard Test Methods for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 5.5 lb. (2.49 kg.) Rammer and 12-in (305 mm) Drop.

2. ASTM D1557 - Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures , Using l O lb. (4.54 kg.) Rammer and 18-in (457 rnm)Drop.

3. ASTM 02487 - Standard Test Method for Classification of Soils for Engineering Purpose s.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

SECTION 31 10 00 | SITE CLEARING

1.03 QUALITY ASSURANCE

A. OWNER shall employ a commercial testing lab in-place density tests to verify suitability of the existing subgrade soils at the bottoms of excavations.

1.04 EXCAVATION BELOW GRADE

A. Excavation shall be accomplished by methods which preserve the undisturbed state of the subgrade soils. Excavation equipment shall be satisfactory for carrying out the work in accordance with these Specifications. In no case shall the earth be plowed, scraped, or dug with machine1y so near to the finished subgrade as to result in excavation of, or disturbance of, material below finished subgrade.

During final excavation to subgrade level, take whatever precautions are required to prevent disturbance and remolding. Material which has been soft or loose or otherwise unsatisfactory to support the structure as a result of the excavation operation shall be removed and replaced as specified below. Compact subgrade to at least 95 percent of maximum density obtainable by ASTM D698, remove all boulders in excess of eight (8) inches at the subgrade surface. The ENGINEER, will be the sole judge as to whether the work has been accomplished satisfactorily.

B. When the excavation has reached prescribed depths, the ENGINEER shall be notified and he will inspect conditions. If materials and conditions are not satisfactory to the ENGINEER, the ENGINEER will issue instructions as to the procedures to be taken.

1. If the bottom of the excavation is taken below the limits shown on the Drawings, specified or directed by the ENG INEER , it shall be refilled at the CONTRACTOR's expense with concrete, 8-inch layers of compacted structural fill placed and compacted with acceptable material. The type of material to be used shall be the ENGINEER' s option.

2. If the CONTRACTOR does not control surface runoff to maintain a firm and dry subgrade, or fails to postpone final excavation immediately above the subgrade until shortly before placing new work, or otherwise fails or neglects to conduct the excavation work properly so the surface of the subgrade is in proper condition prior to construction, the CONTRACTOR shall remove the unsuitable material and replace it at his own expense with acceptable material. The condition of the replaced subgrade shall be acceptable to the ENGINEER before any work is placed thereon.

3. If the subgrade. in its undisturbed natural condition, at or below the normal grade of the excavation as indicated on the Drawings is unsuitable for foundations , it shall be removed to such depth and width as may be required and be replaced with suitable material all as directed by the ENGINEER. If additional costs are involved, adjustments to the Contract will be made on the basis of prices agreed upon by the OWNER and CONTRACTOR in accordance with the provisions of the Contract Documents.

C. All excavations for pipes shall be backfilled with structural fill compacted as specified or encased in concrete.

D. Where it is impractical to use large equipment for compaction or when such methods, in the opinion of the ENGINEER, are disturbing the surrounding natural subgrade, the fill shall be placed using hand-operated mechanical compactors. The lift thickness shall not exceed six (6) inches measured before compaction when hand-operated equipment is used.

PART 2 PRODUCTS NONE - *NIA*

2.01 MATERIALS

A. Fill Material: **As specified per Soils Report. Section 31 01 00 - Grading: As specified in Section 31 23 23 - Fill and Backfill;**

PART 3 EXECUTION

3.01 SITE CLEARING

A.

B. Minimize production of dust due to clearing operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

3.02 Existing Utilities and Built Elements

A. Coordinate work with utility companies; notify before starting work and comply with their requirements; obtain required permits.

B. Protect existing utilities to remain from damage.

C. Do not disrupt public utilities without permit from authority having jurisdiction.

D. Protect existing structures and other elements that are not to be removed.

3.03 VEGETATION

A. Scope: Remove trees, shrubs, brush, and stumps in areas to be covered by building structure, paving, playing fields, lawns , and planting beds.

B. Do not begin clearing until vegetation to be relocated has been removed.

C. Do not remove or damage vegetation beyond the **limits indicated on drawings.**

D. Install substantial, highly visible fences **at least 3 feet high at vegetation removal limits.**

E. In areas where vegetation must be removed but no construction will occur other than pervious paving, remove vegetation with minimum disturbance of the subsoil.

F. Vegetation Removed: Do not burn, bury, landfill, or leave on site, except as indicated.

1. Chip, grind, crush, or shred vegetation for mulching, composting, or other purposes; preference should be given to on-site uses.
2. Sod: Re-use on site if possible; otherwise treat as specified for other vegetation removed.

G. Restoration: If vegetation outside removal limits or within specified protective fences is damaged or destroyed due to subsequent construction operations , replace at no cost to the owner.

3.04 DEBRIS

A. Remove debris, junk, and trash from site.

B. Leave site in clean condition, ready for subsequent work.

C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION

SECTION 31 22 00 | GRADING

PART1 GENERAL

1.01 SECTION INCLUDES

A. Removal **and storage** of topsoil.

8. Rough grading the site **for site structures, building pads, and parking areas.**

C. **Replacement of topsoil and finish grading.**

1.02 RELATED REQUIREMENTS

A. Section **3110 00**- **Site Clearing.**

8. Section **31 23 16** - **Excavation.**

C. Section **31 23 16.13** - **Trenching: Trenching and backfilling for utilities.**

D. Section **31 23 23** - **Fill: Filling and compaction.**

1.03 SUBMITTAL$

A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.04 QUALITY ASSURANCE

A. Perform Work in accordance with **City of Clovis Standard Specification for Roadway and Parking Lot Construction.**

1. Maintain **one copy on site.**

PART 2 PRODUCTS

2.01 MATERIALS

A. Top soil excavated on site and local borrow material.

1. Graded.

2. Free of roots, rocks larger than **½ inch subsoil, debris, large weeds, and foreign matter.**

8. Other Fill Materials: See Section **31 23 23.**

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that survey bench mark and intended elevations for the Work are as indicated.

3.02 PREPARATION

A. Identify required lines, levels, contours, and datum.

8. Stake and flag locations of known utilities.

C. **Locate, identify, and protect from damage above and below grade utilities.**

D. Protect site features to remain, including but not limited to **bench marks and survey control points from damage by grading equipment and vehicular traffic.**

3.03 ROUGH GRADING

A. Remove topsoil from entire site, **without mixing with foreign materials.**

8. Do not remove topsoil when wet.

C. Remove subsoil from **areas to be further excavated.**

D. Do not remove wet subsoil **unless it is subsequently processed to obtain optimum moisture content.**

E. See Section **31 23 23 for filling procedures.**

G. **Benching Slopes: Horizontally bench existing slopes greater than 1:4 to key fill material to slope for firm bearing.**

3.04 SOIL REMOVAL AND STOCKPILING

A Stockpile top soil to be re-used on site; remove remainder from site.

B. Stockpiles: Use areas designated on site; pile depth not to exceed **8 feet protect from erosion.**

3.05 FINISH GRADING

A Before Finish Grading:

1. Verify building and trench backfilling have been inspected.
2. Verify subgrade has been contoured and compacted.

B. Remove debris, roots, branches, stones, in excess of **½ inch in size. Remove soil contaminated with petroleum products.**

C. Where topsoil is to be placed, scarify surface to depth of **3 inches.**

D. In areas where vehicles or equipment have compacted soil, scarify surface to depth of § **inches.**

E. Place topsoil in areas indicated.

F. Place topsoil thickness **as indicated.**

G. Place topsoil during dry weather.

H. Remove roots, weeds, rocks, and foreign material while spreading.

I. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.

3.06 FIELD QUALITY CONTROL

A See Section **31 23 23 for compaction density testing.**

3.07 CLEANING

A Remove unused stockpiled **topsoil. Grade stockpile area to prevent standing water.**

B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavating for building volume below grade, footings, pile caps, slabs-on-grade, paving, site structures, and utilities within the building, and general sitework.

B. Trenching for utilities outside the building to utility main connections.

1.02 RELATED REQUIREMENT

A. Section **31 23 03** Fill materials, filling, and compacting.

1.03 PROJECT CONDITIONS

A. Verify that survey bench mark and intended elevations for the Work are as indicated.

PART 3 EXECUTION

2.01 EXAMINATION

A. Verify that survey bench mark and intended elevation for the work are as indicated.

2.02 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. See Section **31 23 23** for additional requirements.

C. Locate, identify, and protect utilities that remain and protect from damage.

D. Notify utility company to remove and relocate utilities.

E. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs, and from excavating equipment and vehicular traffic.

F. Protect plants, lawns, and other features to remain.

2.03 EXCAVATING

A. Excavate to accommodate new structures and construction operations.

B. Notify the Owner of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

C. Preparation for Piling Work: Excavate to working elevations.

D. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.

E. Do not interfere with 45 degree bearing splay of foundations.

F. Cut utility trenches wide enough to allow inspection of installed utilities.

G. Hand trim excavations. Remove loose matter.

H. Remove lumped subsoil, boulders, and rock up to ⅓ cu yd measured by volume.

I. Correct areas that are over-excavated and load-bearing surfaces that are disturbed; see Section 31 23 23.

J. Grade top perimeter of excavation to prevent surface water from draining into excavation.

K. Remove excavated material that is unsuitable for re-use from site.

L. Stockpile excavated material to be re-used in area designated on site in accordance with Section 31 22 00.

M. Remove excess excavated material from site.

2.04 FIELD QUALITY CONTROL

A. Inspection and testing will be performed as directed by the Owner.

B. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at the expense of the Contractor.

2.05 PROTECTION

A. Prevent displacement of banks and keep loose soil from falling into excavation; maintain solid stability.

B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.

END OF SECTION

SECTION 31 23 16.13 | TRENCHING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Backfilling and compacting for utilities outside the building **to utility main connections**.

1.02 RELATED REQUIREMENTS

A. Section **31 22 00** – **Grading**; **Site grading**.

B. Section **31 23 16** – **Excavation**; **Building and foundation excavating**.

C. Section **31 23 23** – **Fill**; **Backfilling at building and foundations**.

1.03 DEFINITIONS

A. Finish Grade Elevations: Indicated on drawings.

B. Subgrade Elevations: Indicated on drawings.

1.04 REFERENCES – City of Clovis Standard Specifications for Roadway and Parking Lot Construction

A. AASHTO T 180 – Standard Specification for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18 in.) Drop; American Association of State Highway and Transportation Officials; **2010**.

B. ASTM C136 – Standard Test Method for Sieve Analysis for Fine and Coarse Aggregates; **2006**.

C. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft0lbf/ft3 (600 kN m/m3));**2007**.

D. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; **2007**.

E. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN m/m3)); **2009**.

F. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System); **2010**.

G. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth); **2005**.

H. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; **2010**.

I. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth); **2010**.

1.05 SUBMITTALS

A. Materials Sources: Submit name of imported materials source.

B. Fill Composition Test Reports: Results of laboratory tests on **proposed and actual materials used**.

C. Compaction Density Test Reports.

1.06 DELIVERY, STORAGE, AND HANDLING

A. When necessary, store materials on site in advance of need.

B. When fill materials need to be stored on site, locate stockpiles where **indicated by the Owner**.

1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
2. Prevent contamination.
3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. General Fill - **Subsoil excavated on-site, Imported borrow, Local borrow**.

B. Structural Fill - **Subsoil excavated on-site, Imported borrow, Local borrow**.

C. Concrete for Fill: Lean concrete.

D. Granular Fill – **Gravel, Angular crushed, natural, washed, stone, free of shale, clay, friable material and debris**.

E. Sand – **Natural river or bank sand, washed, free of silt, clay, loam, friable or soluble materials, and organic matter**.

F. Topsoil – **Topsoil excavated on-site, local borrow**.

2.02 SOURCE QUALITY CONTROL

A. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance **before delivery to site**.

B. If tests indicate materials do not meet specified requirements, change material and retest.

C. Provide materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that survey bench marks and intended elevations for the work are as indicated.

3.02 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. **Locate, identify, and protect utilities that remain and protect from damage**.

C. Notify **utility company** to remove **and relocate** utilities.

D. Protect **bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs from excavating equipment and vehicular traffic**.

3.03 TRENCHING

A. Notify **the Owner** of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

B. Slope banks of excavations deeper than **4 feet** to angle of repose or less until shored.

C. Do not interfere with **45** degree bearing splay of foundations.

D. Cut trenches wide enough to allow inspection of installed utilities.

E. Hand trim excavations. Remove loose matter.

F. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.

G. Remove excavated material that is unsuitable for re-use from site.

H. Stockpile excavated material to be re-used in area designated on site **in accordance with Section 31 22 00**.

I. Remove **excess** excavated material from site.

3.04 PREPARATION FOR UTILITY PLACEMENT

A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with **general fill**.

B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.

C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

3.05 BACKFILLING

A. Backfill to contours and elevations indicated using unfrozen materials.

B. Fill up to **subgrade elevations unless otherwise indicated**.

C. Employ a placement method that does not disturb or damage other work.

D. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.

E. Maintain optimum moisture content of fill materials to attain required compaction density.

F. Granular Fill: Place and compact materials in equal continuous layers not exceeding **6 inches compacted depth**.

G. Soil Fill: Place and compact material in equal continuous layers not exceeding **8 inches compacted depth**.

H. Slope grade away from building minimum **2 inches in 10 ft, unless noted otherwise**. Make gradual grade changes. Blend slope into level areas.

I. Correct areas that are over-excavated.
   1. Other areas: Use **general fill**, flush to required elevation, compacted to minimum **97** percent of maximum dry density.

J. Compaction Density Unless Otherwise Specified or Indicated:

   1. Under **paving and similar construction**, **or 100 percent of maximum dry density**. (ASTM D698)

   2. At **slabs on grade** **95** **percent of maximum dry density**. (ASTM D1557)

K. Reshape and re-compact fills subjected to vehicular traffic.

3.06 BEDDING AND FILL AT SPECIFIC LOCATIONS

A. Use general fill unless otherwise specified or indicated.

B. **Utility Piping, Conduits, Duct Bank:**
   1. Bedding: Use **granular fill, general fill**.
   2. Cover with **general fill**.
   3. Fill up to **subgrade elevation**, **finish grade elevation**.
   4. Compact in maximum **8 inch** lifts to **95 percent of maximum dry density**.

C. At **Pipe Culverts**:
   1. Bedding: Use **granular fill, general fill, structural fill, sand**.
   2. Cover with **general fill**.
   3. Fill up to **subgrade elevation**, **finish grade elevation**.
   4. Compact in maximum **8 inch** lifts to **95 percent of maximum dry density**.

D. At **French Drains**:
   1. Use **granular fill**.
   2. Fill up to **8 inches** **below finish grade**.
   3. Compact to **95 percent of maximum dry density.**

3.07 FIELD QUALITY CONTROL

A. **Compaction density testing will be performed on compacted fill in accordance with ASTM D6938**.

B. **Results will be evaluated** in relation to compaction curve determined by testing un-compacted material in accordance with **ASTM D698 ("standard Proctor"), ASTM D1557 ("modified Proctor")**.

C. If tests indicate work does not meet specified requirements, **remove work, replace and retest**.

3.08 CLEANING

A. Leave unused materials in a neat, compact stockpile.

B. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.

C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 31 23 23 | FILL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Filling , backfilling, and compacting for building volume below grade, footings, slabs-on-grade, paving, site structures, and utilities within the building.

B. Backfilling and compacting for utilities outside the building to utility main connections.

C Filling holes, pits, and excavations generated as a result of removal (demolition) operations.

1.02 DEFINITIONS

A. Satisfactory Materials: Materials classified in accordance with ASTM D2487 as SW, SP, SM, SC, SW-SM, SW-SC, SP-SM, SP-SC, SC-SM, GW, GP, GM, GC, GW-GM, GW-GC, GP-GM and GP-GC and free of roots and other organic matter, trash, debris, frozen materials and stones larger than 3-inches in any dimension for select fill or 6 inches in any dimension for common fill, and as further defined in the project Geotechnical report, can be considered satisfactory.

B. Unsatisfactory Materials: Materials that are not in accordance with the requirements for satisfactory materials are unsatisfactory. In addition, materials, which include man-made fills, refuse or stabilized backfills from previous construction are unsatisfactory.

C. Sub-excavation: Excavation of existing materials to specified depths or elevations below the bottom footings or foundations for the purpose of removing unsound or undesirable soil materials for replacement with select fill or other specified fill material.

D. Compaction: Degree of compaction is a percentage of maximum density obtained by the test procedure described in ASTM D1557 and is abbreviated in this section as a percent of laboratory maximum density.

E. Proof rolling: Compaction method using a 10 ton steel or pneumatic wheeled roller to locate and identify weak or compressible zones in exposed sub-grade soils. For this specification proof rolling will include a minimum of ten (10) passes with an approved roller and must be observed and approved by the presence of the Project Engineer.

1.03 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)/American Society for Testing and Materials (ASTM).

1. ANSI/ASTM C136 – Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ANSI/ASTM D1557 – Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 10 lb (4.54 Kg) Rammer and 18 inch (457mm) Drop.
3. ASTM D 2487 – Classifications of Soils for Engineering Purposes (Unified Soil Classification System).
4. ASTM D2922 – Test Methods for Density of Soil-Aggregate Mixtures in Place by Nuclear Methods (Shallow Depth).
5. ASTM D3017 – Test Methods for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
6. ASTM D4318 – Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

1.04 SUBMITTALS

A. Submit and obtain approval prior to beginning earthwork operations:

1. Name and location of source(s) proposed for imported soils and aggregate materials.
2. Certified test reports and analysis from identified proposed source, certifying that the soils and aggregate materials proposed for use on the project conform to the specified requirements.

3. Imported materials to be supplied from the same source throughout the work. Change of source will require submittal of certified test reports as per 2. above, for the proposed soil materials and the Engineer's approval.

B. During earthwork operations:

1. Certified test reports and analysis for all tests conducted in accordance with 3.05, Field Quality Control, this Section.

C. 15 days prior to Final Acceptance:

1. Accurately record, on a set of the construction plans, actual locations of all existing improvements, monuments and improvements remaining as well as any changes to locations, numbers, etc to the new improvements, structures, etc. as may have been approved during construction.
2. Actual locations to be shown with horizontal dimensions, elevations, inverts and slope gradients.

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. Select Granular Material

1. General Requirements:

Select granular material consist of materials classified as GW, GP, SW, SP, by ASTM D2487. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be a greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140.

2. Non-expansive Fill:

Non-expansive fill shall consist of satisfactory materials free from rocks greater than 1" in diameter in any direction. The liquid limit of such material shall not exceed 35 percent and the plasticity index shall not be greater than 12 percent or less than 4 percent when tested in accordance with ASTM D4318. The sodium sulfate content shall not exceed 0.2 percent by dry weight of soil and soil solubility shall be less than 1.5 percent. The select fill shall be placed in 8" loose to 6" maximum compacted lifts with each lift tested and accepted prior to placement of the next lift. The select fill should be moisture conditioned to +/- 2% of optimum moisture then compacted to a minimum of 95% of maximum dry density as determined by a Modified Proctor (ASTM D1557).

3. CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock or crushed gravel placed beneath a building slab with a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Gradation of capillary water barrier shall meet gradation requirements of ASTM C33 coarse aggregate Size 67.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that survey bench marks and intended elevations for the Work are as indicated.

B. Identify required lines, levels, contours, and datum locations.

C. Verify sub-drainage, damp-proofing, or waterproofing installation has been inspected.

3.02 PREPARATION

A. Scarify and proof roll subgrade surface to a depth of 6 inches to identify soft spots.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill material as approved by the Engineer.

C. Compact subgrade to density as specified in the project plans and specifications.

D. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.

E. Identify required lines, levels, contours, and datum.

F. Notify public utility authorities in accordance with City regulations and coordinate verification of existing utilities locations. Contractor shall remain responsible for the location and work in and around any utilities.

G. Confirm, stake and flag locations of known utilities.

H. Coordinate with utility companies, the removal or relocation of utility lines or facilities designated to be relocated on the drawings.

I. Protect above the below grade utilities designated to remain or any other utilities within the site.

J. Protect plants and other features designated to remain as part of final landscaping.

K. Protect benchmarks, existing structures, fences, paving, and curbs and other improvements on the site and along the access route, designated to remain, from excavating equipment and vehicular traffic.

L. The Contractor shall remain responsible for any damage to existing structural improvements within the site or adjoining properties that may be affected by the Contractor's operation. The Contractor shall hold harmless, the Owner and Engineer from any damage or injury caused by the Contractor's operations.

3.03 FILLING

A. Fill to contours and elevations indicated using unfrozen materials.

B. Fill up to subgrade, finish grade elevations unless otherwise indicated.

C. Granular Fill: Place and compact materials in equal continuous layers not exceeding 6 inches compacted depth

D. Soil Fill: Place and compact material in equal continuous layers not exceeding 8 inches compacted depth.

E. Slope grade away from building as shown on the Project site grading plan, unless noted otherwise. Make gradual changes. Blend slope into level areas.

F. Remove all roots, brush, heavy sods, heavy growth of grass, decayed vegetable matter, rubbish, and other unsatisfactory materials from areas to receive fill materials.

G. Existing slopes greater than four horizontal to one vertical which are to receive fill shall be plowed, stepped or broken up in such manner that the fill material will bond with the existing surface.

1. Prepared surfaces that are to receive fill shall be scarified, wetted or dried, as required, to obtain specified moisture content and compacted to 95% of maximum density.

H. Fills and embankments shall be constructed in the locations and to lines and grades indicated. Completed fill will conform to shapes indicated by plan and typical sections and contours. Make grade changes gradual. Blend slope into level areas.

I. Place fill materials in continuous horizontal layers of 8 inch (6-inch, where hand held compaction equipment is to be used for compaction) loose depth for the full width of the cross section and compacted to 95% of maximum density or to the density shown on the plans.

J. Maintain moisture content to within plus or minus 2 percent of optimum moisture content as determined from laboratory tests of the fill materials.

K. Do not backfill over porous, wet, frozen or spongy subgrade surface.

L. Use placement methods that will not disturb or damage existing structures or other work.

1. Backfill adjacent to structures shall be placed and uniformly compacted in such manner as to prevent wedging action or eccentric loading upon or against the structures.

M. Finished graded surfaces of all areas covered by the project, including excavated and filled sections and adjacent transition areas, shall be uniformly smooth-graded.

1. Slope grade away from buildings at minimum slope of ¼-inch per foot (2%) for minimum of 10-feet unless noted otherwise.

N. Remove surplus fill materials and unacceptable materials from the site and dispose of at acceptable disposal sites.

O. Over-excavation beyond the limits and depths required by the Contract Documents shall be replaced to the specified lines and grades at no additional cost to the Owner with select fill or learn concrete or other material approved, in writing, by the Engineer.

3.04 TOLERANCES

A. Top Surface of General Filling: Plus or minus 0.10 foot from required elevations.

B. Top Surface of Filling Under Paved Areas, 0.10 foot Plus or minus 1 inch from required elevations.

3.05 FIELD QUALITY CONTROL

A. Inspection and testing will be performed as directed by the Project Engineer.

B. If tests indicated Work does not meet specified requirements, remove Work, replace and retest at the expense of the Contractor.

3.06 CLEANING

A. Leave unused materials in a neat, compact stockpile.

B. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.

C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 32 11 23 | AGGREGATE BASE COURSE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing, hauling, and placing Aggregate base course.

B. Paving aggregates.

1.02 REFERENCE STANDARDS

A. City of Clovis Standard Specification for Public Works Construction, "Section 302 – Aggregate Base Course Construction"

B. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; **2006**.

C. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3));**2007**.

D. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; **2007**.

E. ASTM D1557 – Standard Test Methods for laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN m/m3));**2009**.

F. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System);**2010**.

G. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth);**2005**.

H. ASTM 4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils;**2010**.

I. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth);**2010**

1.03 DELIVERY, STORAGE, AND HANDLING

A. When necessary, store materials on site in advance of need.

B. When aggregate materials need to be stored on site, locate stockpiles where **designated by the Engineer**

1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
2. Prevent contamination.
3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.01 MATERIALS

Base course shall be composed of materials consisting of crushed stone, crushed or screened gravel, caliche, sand, or a combination of such materials. Base course shall be free from vegetable matter and all other deleterious materials, including silt and clay balls.

Sieve Sizes	I-B	II-B
2"		
1½"		
1"	100	100
¾"	80-100	85-100
⅜"	-	-
No. 4	30-60	40-70
No. 10	20-45	30-55
No.200	3-10	4-12
2FF*	50% or	50% or
	more	more

**Fractured faces tests shall be performed on the material retains on the number 4 sieve. A face shall be counted as fractured whenever one-half(½) or more of the surface, when viewed normal to the face, is fractured*

Type I-B, Type II-B aggregated shall have a percent wear of fifty (50) or less at 500 revolutions when tested in accordance with AASHTO T 96 and the coarse aggregate shall have a soundness loss of eighteen (18) or less when tested in accordance with AASHTO T-104 using magnesium sulfate solution and a test duration of five (5) cycles. For caliche aggregates the soundness loss shall be twenty two (22) or less. The liquid limit shall be twenty five (25) or less and the plastic index shall be six (6) or less.

Samples will be tested to determine the quality of the aggregate in terms of Los Angeles wear and soundness loss of aggregate

Testing will be done by an approved Independent Testing Laboratory (ITL). Test will take a minimum of fifteen (15) working days to accomplish.

Contractor shall submit samples of the aggregate for source approval. If testing indicates the material meets, the Contractor may begin crushing operations from the material source.

For commercial sources, the Contractor may maintain an ongoing approval by submitting samples on a semiannual basis in accordance with procedures established.

The subgrade, subbase, or base course upon which the base course is to be placed shall be cleaned of all loose and deleterious materials and shall be free from frozen material.

Top six (6) inches shall meet the density requirements for Subgrade Preparation, Mixing and Placing, immediately prior to placing the base course.

At the request of the Engineer the subgrade shall be proofrolled with a thirty (30) ton roller and soft areas corrected.

2.02 SOURCE QUALITY CONTROL

A. Where aggregate materials are specified using ASTM D2487 classification, test and analyze samples for compliance **before delivery to site.**

B. If tests indicate materials do not meet specified requirements, change material and retest.

C. Provide materials of each type from same source throughout the work.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that survey bench marks and intended elevations for the work are as indicated.

B. Verify substrate has been inspected, gradients and elevations are correct and is dry.

3.02 PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place aggregate on soft, muddy, or frozen surfaces.

3.03 INSTALLATION

A. Spread aggregate over prepared substrate to a total compacted thickness of **6" inches where applicable.**

B. Under **Bituminous Concrete Paving**

1. Place **aggregate base course to a total compacted thickness of 6" inches.**

2. Compact to **95 percent of maximum dry density**. (ASTM D1557)

C. Under **Portland Cement Concrete Paving** no base course material is required.

D. Level and contour surfaces to elevations and gradients indicated.

E. Add small quantities of fine aggregate to coarse aggregate as appropriate to assist compaction.

G. Add water to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content.

H. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.04 TOLERANCES

A. Flatness: Maximum variation of **0.10 feet measured with 10 foot straight edge.**

B. Scheduled Compacted Thickness: Within **0.05 feet.**

C. Variation From Design Elevation: Within **0.05 feet.**

3.05 FIELD QUALITY CONTROL

A. **Compaction density testing will be performed on compacted aggregate base course in accordance with ASTMD2922.**

B. **Results will be evaluated in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557.**

C. If tests indicate work does not meet specified requirements, **remove work, replace and retest at no additional cost to the owner.**

D. Frequency of Tests as per the Engineer.

3.06 CLEANING

A. Leave unused materials in neat, compact stockpile.

B. Remove unused stockpiled materials, leave area in clean and neat condition. Grade stockpile area to prevent standing surface water.

C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 32 12 16 | ASPHALT PAVING

PART1 GENERAL

1.01 SECTION INCLUDES

A. Aggregate base course.
B. Single course bituminous concrete paving.
C. Double course bituminous concrete paving.
D. Surface sealer.

1.02 REFERENCE STANDARDS

A. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types; The Asphalt Institute:1994.
B. ASTM D2172 - Standard Specification for Quantitative Extraction of Bitumen from Bituminous Paving Mixture.
C. ASTM D2041 - Standard Specification for Theoretical Maximum Specific Gravity for Bituminous Paving Mixture:2003.
D. ASTM D5444 - Standard Specifications for Mechanical size analysis of Extracted Aggregate
E. ASTM D6926 - Standard Practice for Preparation of Bituminous Specimens using Marshall Apparatus; **2010**

1.03 QUALITY ASSURANCE

A. The owner will accept the constructed product based on the Engineers inspection and on Laboratory testing for conformance with the design specifications.
B. Mixing Plant: Conform to State of New Mexico State Department of Transportation Standard Specifications for Highway and Bridge Construction.
C. Obtain materials from same source throughout.

1.04 FIELD CONDITIONS

A. Do not place asphalt when ambient air or base surface temperature is less than 40 degrees F or surface is wet or frozen.
B. Place bitumen mixture when temperature is not more than 15 degrees F below bitumen supplier's bill of lading and not more than maximum specified temperature.

PART 2 PRODUCTS

2.01 MATERIALS

All materials shall be tested in accordance with applicable AASHTO methods or other test procedures designated by the OWNER. All questions arising as to interpretation of test procedures shall be decided by the OWNER. Material that is improperly graded or segregated, or fails to meet the requirements herein provided, shall be corrected or removed and disposed of immediately as directed by the Engineer, at the Contractor's expense.

A. Type I. Each fraction of Type I PMBP coarse aggregate shall have a percent wear of forty (40) or less at 500 revolutions when tested in accordance with AASHTO T 96 and the coarse aggregate shall have a soundness loss of fifteen (15) or less when tested in accordance with AASHTO T 104 using magnesium sulfate solution and a test duration of five (5) cycles. All material passing the No. 40 sieve shall be non-plastic. The amount of crushing shall be regulated so that at least seventy five percent (75%), by dry weight, of the plus No. 4 sieve material shall have a minimum of two (2) fractured faces. The combined aggregate shall have a minimum sand equivalent of forty five (45).

B. Fractured Faces. A face will be counted as fractured whenever one-half (½) or more of the surface, when viewed normal to the face, is fractured.

2.02 Production.

When producing aggregates for PMBP natural fines shall be removed by screening and stockpiled separately. The Contractor shall use as a minimum, the U.S. No. 4 sieves for this screening operation. The contractor may use a larger screen if needed to properly control the crushing and screening operation. The aggregate retained on the scoping screen sieve shall then be crushed, separated and stockpiled as specified herein. Crushing operations shall be regulated in a manner that produces material within the specified gradation band.

When producing aggregates for PMBP the crushed material shall be separated into at least two (2) stockpiles of fine and coarse aggregates.

The coarse aggregate shall have not more than four percent (4%) passing the U.S. No. 10 sieve. In the case of a wet pit, when screening becomes difficult, the Engineer may authorize the coarse aggregate passing the U.S. No. 10 sieve *to* be increased to a maximum often percent (10%). The fine aggregate shall have no more than five percent (5%) of the material retained on the separating screen The Separating screen shall be that screen where separation between coarse and fine aggregate occurs depending on the material.

2.03 Combining.

When the crushed materials from the stockpiles are combined, the product of such combination shall meet the gradation requirements. In order to meet the specified mix design criteria, blending sand may be added up to a maximum of twenty percent (20%). The actual percentage will be determined based on tests performed by the Contractor. The Contractor shall furnish blending sand from what-ever source necessary to meet mix design gradation requirements.

2.04 Acceptance of Aggregate.

The liquid limit, sand equivalent and fractured face count of PMBP aggregate will be determined from representative samples taken after the aggregate materials have been blended and prior to mixing with bituminous material. The test results from these samples will be the basis for acceptance of such aggregate. The Engineer may sample and test the aggregate at any time during production or stockpiling.

The mix design proposal shall contain, as a minimum, the following:

1. The name and address of the testing organization and the person responsible for the testing.
2. The specific location(s) of the source(s) of aggregate and blending sand.
3. The supplier, refinery and type of asphalt cement, and the source and type of mineral filler and the percentage of each to be used.
4. The mineral aggregate gradation in each stockpile.
5. The proposed mix design gradation.
6. The results of all testing, determinations, etc. such as: Specific gravity of each component, water absorption, sand equivalent, loss on abrasion (LA wear), soundness loss, fractured faces, immersion compression results, Marshall Stability and flow, asphalt absorption, percent air voids, voids in mineral aggregate, and bulk density.

2.05 Mix Temperature Requirements.

The temperature of the bituminous mixture at discharge from the mixer shall not exceed 300°F and shall not be less than 250°F. When polymer modified asphalts are used the maximum temperature shall not exceed 350°F. The mixing temperature shall be as directed by the Engineer, and the temperature shall be maintained within a range of plus or minus twenty degrees (20°}F.

2.06 Haul Equipment.

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of commercial agent to prevent the mixture from adhering to the bed. If diesel fuel is used it shall be applied to the truck bed with a fine spray fogging device with the truck bed in the maximum raised position and allowed to drain before the bed is lowered. There shall be no puddles of diesel fuel or material from the previous load allowed in the truck bed. Bituminous material place in truck beds with puddle or draining diesel fuel shall be wasted at the Contractor's expense.

Each truck shall have a cover of canvas or other suitable material of sufficient size to protect the mixture from the weather to be used as directed by the Engineer.

2.07 Pavers.

Pavers shall be self-contained, self-propelled units, provided with an activated screed or a strike-off assembly, heated if necessary, and capable of spreading and finishing courses of PMBP material to the widths and thickness as specified in the contract.

Pavers shall be operated at a speed no greater than three (3) MPH. Materials introduced in front of the screed shall maintain a consistent depth to avoid variation in pressure on the screed. The auger box shall be maintained at 1/3 to 2/3 full.

Pavers shall be equipped with a receiving hopper sufficient capacity to effect a uniform spreading operation. The hopper shall be equipped with a distribution system capable of maintaining a uniform amount of mixture in front of the screed.

The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The screed shall be adjustable or both height and crown and shall be equipped with a controlled heating device.

The screed or strike-off assembly shall produce a finished surface of an even and uniform texture for the full width being paved without tearing, shoving or gouging the mixture. Screeds shall include any strike-off device operated by tamping or vibrating action.

The bituminous paver shall be equipped with an automatic leveling device controlled from an external guide. The initial pass for each course shall be made using a paver equipped with a forty (40) foot minimum external reference, except that this requirement will not apply when PMBP is placed adjacent to Portland cement concrete pavement or when short lengths of PMBP placement is required. Subsequent passes and passes adjacent to PCCP shall utilize a matching device of one (1) foot minimum length riding on the adjacent lay.

2.08 Compaction Equipment.

Equipment proposed for use in the compaction of PMBP shall be approved by the Engineer prior to use. All rollers shall be self-propelled, in good condition and capable of reversing without backlash. One (1) roller shall be either a steel wheel vibratory roller weighting a minimum of six (6) tons or a smooth faced wheel roller of two (2) axle or three (3) axle tandem design weighting a minimum of ten (10) tons. The other roller shall be a self-propelled pneumatic tired roller so constructed that the average ground contact pressure may be varied between forty (40) and ninety (90) pounds per square inch.

2.09 Placement Operations.

The asphalt concrete mixture shall be placed on the approved surface, spread and struck off to the grade and elevation established. It shall be spread and compacted in layers as shown on the plans or as directed by the Engineer. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

The subgrade, base course or BTB upon which the PMBP is to be placed shall be cleaned of all loose material or other deleterious materials prior to placement of the PMBP. These surfaces shall be free of frozen material and the moisture and density requirements of the applicable Section shall be met prior to placement of the new PMBP.

On areas there irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be dumped, spread and leveled to give the required compacted thickness.

2.10 Temperature & Weather Limitations.

PMBP shall not be placed on wet or frozen surfaces; when the ambient temperature is below forty five degrees (45°)F; when the chill factor is below thirty five degrees (35°)F; or when weather conditions otherwise prevent the proper handling and finishing of the PMBP.

2.11 Placement Temperature.

The Engineer will determine a minimum placement temperature within a range from 220°F to 300°F. When polymer modified asphalts are used the maximum temperature shall be 350°F. The established placement temperature, which is measured immediately behind the laydown machine, shall not vary more than plus or minus twenty degrees (20°)F from that established by the Engineer.

2.12 Compaction.

Immediately after the bituminous mixture has been spread, struck-off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted.

The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations and the selection of roller types shall provide the specified pavement density. Rolling operations shall not disturb the typical section placed by the paver.

Rollers shall be operated at speeds less than three (3) MPH and slow enough to minimize the displacement of the bituminous mixture. The use of equipment which results in excessive crushing of aggregates will not be permitted. At least two (2) rollers shall be used for compaction. Both steel faced and pneumatic rollers are required. If the pneumatic roller leaves marks that require a final rolling, additional passes with a static wheel roller will be required to remove the marks.

Any displacement occurring as a result of the reversing of direction of a roller, or from other causes, shall be corrected immediately by the use of rakes and addition of fresh bituminous mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture. To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted. Diesel fuel or other petroleum diluents are not acceptable.

Along forms, curbs, headers, walls and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, a trench roller or cleated compression strips under the roller may be used to transmit compression to the depressed area.

Mixtures which become loose, broken, mixed with dirt, segregated or are defective shall be removed replaced with fresh hot bituminous mixture, and compacted to conform with the surrounding area, at the Contractor's expense. Areas showing excess or deficiency of bituminous material shall be corrected immediately as directed by the Project Manager.

2.13 FIELD QUALITY CONTROL

A Provide field inspection and testing. Take samples and perform tests in accordance with **quality control requirements to be established by Owner.**

2.14 PROTECTION

A Immediately after placement, protect pavement form mechanical injury for **one day or until surface temperature is less than 140 degrees F.**

END OF SECTION

SECTION 32 13 13 | CONCRETE PAVING

PART1 GENERAL

1.01 SECTION INCLUDES

A. Concrete sidewalks, stair steps, curbs, gutters, parking areas, and valley curbs.

1.02 REFERENCE STANDARDS

A. City of Clovis Standard Specifications for Roadway and Parking Lot Construction

B. ACI 2211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and **Mass** Concrete; American Concrete Institute International:1991 **(Reapproved 2002).**

C. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International; **2000.**

D. ACI 305R - Hot Weather Concreting; American Concrete Institute International; **2010.**

E. ACI 306R - Cold Weather Concreting; American Concrete Institute International; **2010.**

F. ASTM C33 - Standard Specification for Concrete Aggregates; **2011.**

G. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; **2010.**

H. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; **2011**

I. ASTM C150 - Standard Specification for Portland Cement; **2011**

J. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; 201Ob .

K. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete; **2010a.**

L. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete; **2007.**

M. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete; **2010a.**

N. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete; **2008.**

0. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (non-extruding and Resilient Bituminous Types); **2004a (Reapproved 2008).**

1.03 SUBMITTAL$

A. Product Data: Provide data on concrete mix designs proposed for usage on this Project Site Mix designs are to be approved by the Engineers prior to usage.

B. Design Data: Contractor Is advised to review the Project plans for pavement thickness, design strengths, and typical details.

PART 2 PRODUCTS

2.01 PAVING ASSEMBLIES

A. Comply with applicable requirements of City of Clovis Standard Specifications for Roadway and Parking Lot Construction.

B. Design paving for parking and light duty commercial vehicles.

C. Concrete Sidewalks: **3,000 psi 28 day concrete, 4 inches thick 5%-7% air entrainment, 4" maximum slump.**

D. Parking Area Pavement: **4,000 psi 28 day concrete, 6 inches 5%-7% air entrainment, 1"-3" slump.**

2.02 FORM MATERIALS

A. Form Materials Conform to ACI 301.

B. Wood or Steel form material profiled to suit conditions.

C. Join Filler: Preformed non-extruding bituminous type (ASTM D1751).

1. Thickness: ½ inch.

2.03 CONCRETE MATERIALS

A. Obtain cementitious materials from same source throughout.

8. Cement: ASTM C150 **Normal Type** I-II L, A.

C. Fine and Coarse Mix Aggregates: ASTM C33 Maximum aggregate size#57.

D. Fly Ash: ASTM C618, Class **C or F.**

E. Water: Clean, and not detrimental to concrete.

F. Fiber Reinforcement: Alkali-resistant glass fibers; Synthetic fibers shown to have long-term resistance to deterioration when in contact with alkalis and moisture.

G. Air Entrainment Admixture: ASTM C260.

H. Chemical Admixtures: ASTM C494/C494M, Type A - **Water** Reducing

2.04 CONCRETE MIX DESIGN

A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 recommendations.

8 . Concrete Strength: Establish required average strength for **each type of concrete on the basis of field experience or trial mixtures, as specified in ACI 301.**

1. For trial mixtures method, employ independent testing agency acceptable to **the Owner for preparing and reporting proposed mix designs.**

C. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer

D. Fiber Reinforcement: Add to mix at rate of **1.5 pounds per cubic yard, or as recommended by manufacturer for specific project conditions.**

E. Concrete Properties:

1. Compressive Strength, when tested in accordance with ASTM C39/C39M at **28 days.**

2. Fly Ash Content: Maximum 20% of cementitious materials by weight.

3. Cement Content: Minimum 517 lb per cubic yard.

4. Water-Cement Ratio: Maximum **0.45 percent by weight.**

5. Total Air Content: **5%-7% determined in accordance with ASTM C173/C173M.**

6. Maximum Slump: **4 inches.**

7. Maximum Aggregate Size: **#57.**

2.05 MIXING

A. Transit **Mixers:** Comply with **ASTM C94/C94M.**

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted **subgrade is acceptable and ready to support paving and imposed loads.**

B. Verify gradients and elevations of base are correct.

3.02 PREPARATION

A. Moisten-subgrade to minimize absorption of water from fresh concrete.

B. Coat surfaces of catch **basin frames with oil to prevent** bond **with concrete pavement.**

C. Notify **the Owner minimum 24 hours prior to commencement of concrete operations.**

3.03 FORMING

A. Place and secure forms to correct location, dimension, profile, and gradient.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.04 COLD AND HOT WEATHER CONCRETING

A. Follow recommendations of ACI 305R when concreting during hot weather.

B. Follow recommendations of ACI 306R when concreting during cold weather.

C. Do not place concrete when base surface temperature is less than **40 degrees F, or surface is wet or frozen.**

3.05 PLACING CONCRETE

A. Coordinate installation of snow melting components.

B. Place concrete **in accordance with ACI 304R.**

C. Place concrete continuously over the full width of the panel and between predetermined construction joints. **Do not break or interrupt successive pours such that cold joins occur.**

3.06 JOINTS

A. Align curb, gutter, and sidewalk joints.

B. Place **3/8 inch** wide **expansion** joints at **60 foot intervals and to separate paving from vertical surfaces and other components.**

1. Form joints with joint filler extending from bottom of pavement to within **½ inch of finished surface. All expansion joints in the concrete pavement, curb and gutter, and sidewalks are to be sealed.**

C. Provide a **complete jointing plan to the Owner for approval prior to concrete placement.**

D. Provide keyed joints as indicated.

E. Saw cut contraction joints **3/16 inch wide at optimum time after finishing. Cut 1/3 into depth of slab. For concrete curb and gutter contraction joints should be placed at 15 feet to 20 feet intervals. For concrete sidewalks, the contraction joints should be placed at five (5) foot intervals.**

3.07 FINISHING

A. Parking Area Paving: Light broom, texture perpendicular to pavement direction.

8. Sidewalk Paving: Light broom, texture perpendicular to direction of travel.

C. Curbs and Gutters: Light broom, texture parallel to pavement direction.

D. Inclined Vehicular Ramps: Broomed perpendicular to slope.

E. Place curing compound **on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.**

3.08 FIELD QUALITY CONTROL

1. Submit proposed mix design of each class of concrete to the Owner for review prior to commencement of concrete operations.
2. Tests of concrete and concrete materials may be performed at any time to ensure conformance with specified requirements.

3.09 PROTECTION

A. Immediately after placement, protect pavement form premature drying, excessive hot or cold temperatures, and mechanical injury.

8. Do not permit **vehicular traffic over pavement for 7 days minimum after finishing.**

END OF SECTION

SECTION 32 1723 - PAVEMENT MARKINGS

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 painted markings applied to asphalt and concrete pavement.

B. Related Requirements:

1. Section 09 9113 "Exterior Painting" for painting exterior concrete surfaces other than pavement, if required.
2. Section 09 9600 "High-Performance Coatings" for tile-like coatings.

1.3 REFERENCE STANDARDS

A. FHWA MUTCD - Manual on Uniform Traffic Control Devices for Streets and Highways; U.S. Department of Transportation, Federal Highway Administration; *https://mutcd.fhwa.dot.gov*; current edition.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to marking pavement including, but not limited to, the following:

a. Pavement aging period before application of pavement markings.
b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.
2. Application instructions.

B. Shop Drawings: For pavement markings.

1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Samples: For each exposed product and for each color and texture specified; on rigid backing, 8 inches square.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer which indicates installer meets the quality assurance requirements set forth in “Quality Assurance” Article.

B. Material Certificates: From manufacturer certifying products comply with specifications.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the authorities having jurisdiction for pavement-marking work.

B. Installer Qualifications: A qualified installer that is experienced in performing work similar in material, design, and extent to that indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

1. Installer shall show successful completion of at least 5 projects and shall have at least five years experience in applying pavement markings of the type and extent required for this project.

a. Project Experience List: Include brief description of scope, date, and customer contact information including phone number.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

1. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design: Product selections are based on the manufacturer/product indicated. Subject to compliance with requirements, provide basis-of-design manufacturer/product or a comparable manufacturer/product meeting the quality, appearance, options and performance criteria with that specified.

1. Sherwin-Williams Company (The): 5501 Cass Avenue, Cleveland OH 44101, (800) 321-8194, *https://www.sherwin-williams.com/*
2. Or Approved Equal.

B. Comparable Products: Comparable products of approved manufacturers will be considered in accordance with Section 01 6000 "Product Requirements," and the following:

1. Products are approved by manufacturer in writing for application specified.
2. Products meet performance and physical characteristics of basis-of-design product including published ratio of solids by volume, plus or minus two percent.

C. Source Limitations: Obtain paint materials from single source from single listed manufacturer.

1. Manufacturer's designations that may be listed in the Drawings or on a separate color schedule, if applicable, are for color reference only and do not indicate prior approval.

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "ADA Standards for Accessible Design, current edition" the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

2.3 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint: Fast drying waterborne traffic paint, lead and chromate free, ready mixed, complying with FS TT-P-1952E, Type II, with drying time of less than ten minutes.

1. Basis-of-Design: Product selections are based on the manufacturer/product indicated. Subject to compliance with requirements, provide basis-of-design manufacturer/product or a comparable manufacturer/product meeting the quality, appearance, options and performance criteria with that specified.

a. Sherwin-Williams Company (The); ***Hotline Waterborne Traffic Paint***: 5501 Cass Avenue, Cleveland OH 44101, (800) 321-8194, *https://www.sherwin-williams.com/*
b. Or Approved Equal.

2. Color(s) as follows:

    a. Roadway Markings: As required by authorities having jurisdiction.
    b. Parking Space Lines: White.
    c. International Symbol of Access: Blue reserved exclusively for supplementing White markings for parking spaces for persons with disabilities.

B. Glass Beads: AASHTO M 247, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Allow paving to age for a ***minimum of 30 days*** before starting pavement marking.

B. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.

1. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

B. Clean surfaces thoroughly prior to installation.

1. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods.

2. Where oil or grease are present, scrub affected areas with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application; after cleaning, seal oil soaked areas with cut shellac to prevent bleeding through new paint.

C. Establish survey control points to determine locations and dimensions of markings; provide templates to control paint application by type and color at necessary intervals.

D. Protect existing construction and completed work from damage.

3.3 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Begin pavement marking as soon as practicable after surface has been cleaned and dried.

C. Do not apply paint if temperature of surface to be painted or the atmosphere is less than 55 degrees F or more than 95 degrees F.

D. Apply in accordance with manufacturer's instructions using an experienced technician that is thoroughly familiar with equipment, materials, and marking layouts.

E. Comply with FHWA MUTCD manual (*https://mutcd.fhwa.dot.gov*) for details not shown.

F. Apply markings with mechanical equipment to produce pavement markings, in locations determined by measurement from survey control points; preserve control points until after markings have been accepted.

G. When deficiency in marking drying occurs, discontinue paint operations until cause of slow drying is determined and corrected.

H. Remove and replace markings that are applied at less than minimum material rates; deviate from true alignment; exceed length and width tolerances; or show light spots, smears, or other deficiencies or irregularities.

I. Remove markings in a manner to avoid damage to the surface to which the marking was applied, using carefully controlled sandblasting, approved grinding equipment, or other approved method(s).

J. Replace removed markings at no additional cost to Owner.

K. Apply uniformly painted markings of color(s), lengths, and widths as indicated on the drawings, true, sharp edges and ends.

1. Apply paint in one coat only.
2. Wet film thickness: 0.015 inch, minimum.
3. Width tolerance: Plus or minus 1/8 inch.
4. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.
5. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal..

L. Parking Lots: Apply parking space lines, entrance and exit arrows, painted curbs, and other markings as indicated on Drawings.

1. Mark the International Symbol of Access at indicated parking spaces.
2. Hand application by pneumatic spray is acceptable.

M. Symbols: Use a suitable template that will provide a pavement marking with true, sharp edges and ends, of the design and size indicated.

3.4 DRYING, PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Provide barricades, warning signs, and flags as necessary to prevent traffic crossing newly painted markings.

C. Allow paint to dry at least the minimum time specified by the applicable paint standard and not less than that recommended by the manufacturer.

D. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 1723

SECTION 33 05 13 | MANHOLES AND STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Monolithic concrete manholes with **masonry** transition to lid frame, covers, anchorage, and accessories.

B. Modular precast concrete manhole sections with tongue-and-groove joints **with masonry transition to lid frame**, covers, anchorage, and accessories.

1.02 REFERENCE STANDARDS

A. **City of Clovis Standard Specifications for Public Works Construction**;

B. ACI 530/530.1/ERTA - Building Code Requirements and Specification for Masonry Structures; American Concrete Institute International ; **2009**.

C. ASTM A48/A48M - Standard Specification for Gray Iron Castings ; **2003 (Reapproved 2008)**.

D. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products ; **2009**.

E. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections ; **2009**.

F. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals ; **2008**.

1.03 SUBMITTALS

A. Shop Drawings: Indicate manhole locations, elevations, **piping** sizes and elevations of penetrations.

B. Product Data: Provide manhole covers, component construction **features, configuration, and dimensions**.

1.04 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum **three years documented experience**.

1.05 FIELD CONDITIONS

A. Cold and Hot Weather Requirements: Comply with requirements of ACI 530/530.1/ERTA or applicable building code, whichever is more stringent.

B. Maintain materials and surrounding air temperature to minimum **50 degrees F prior to, during, and 48 hours after completion of masonry work**.

PART 2 PRODUCTS

2.01 MATERIALS

A. Manhole Sections: Reinforced precast concrete in accordance with ASTM C478 (ASTM C478M), with resilient connectors complying with ASTM C923 (ASTM C923M).

B. Concrete: As specified in Section **03 30 00**.

D. Mortar **and Grout**: As specified in Section **04 20 00**, Type S.

2.02 COMPONENTS

A. All manhole components including Lid and Frame, Steps, Anchors, Shaft and Configuration: As specified in the New Mexico Standard Specifications for Public Works Constructor Section 900.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify items provided by other sections of Work are properly sized and located.

B. Verify that built-in items are in proper location, and ready for roughing into Work.

C. Verify excavation for manholes is correct.

3.02 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.

3.03 MANHOLES

A. Place concrete base pad, trowel top surface level.

B. Place manhole sections plumb and level, trim to correct elevations, anchor to base pad.

C. Form and place manhole cylinder plumb and level, to correct dimensions and elevations. As work progresses, build in **fabricated metal items**.

D. Cut and fit for **pipe**.

E. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as required.

F. Set cover frames and covers level without tipping, to correct elevations.

G. Coordinate with other sections of work to provide correct size, shape, and location.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe and fittings for site water lines including **domestic water lines and fire water lines**.

B. **Valves and Fire hydrants**.

1.02 RELATED REQUIREMENTS

A. Section **03 30 00** – **Cast-in-Place Concrete**: **Concrete for thrust restraints**.

B. Section **31 23 16** – **Excavation**: **Excavating of trenches**.

C. Section **31 23 16.13** – **Trenching**: **Excavating, bedding, and backfilling**.

D. Section **31 23 23** - **Fill**: **Bedding and backfilling**.

1.03 REFERENCES

A. ASME B16.18 – Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; **2001 (R2005)** **(ANSI B16.19)**.

B. ASM B16.22 – Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; The American Society of Mechanical Engineers; **2001 (R2005)**.

C. ASTM B88 – Standard Specification for Seamless Copper Water Tube; **2009**.

D. ASTM D1785 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120; **2006**.

E. ASTM D2241 – Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe **ASTM D1784-C900.**

F. ASTM D2466 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; **2006**.

G. ASTM D2855 – Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings; **1996 (Reapproved 2010)**.

H. ASTM D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter; **2010**.

I. ASTM D3139 – Standard Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals; **1998 (Reapproved 2005)**.

J. AWS A5.8/A5.8M – Specification for Filler Metals for Brazing and Braze Welding; American Welding Society; **2004 and errata**.

K. AWWA C104/A21.4 – Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water; American Water Works Association; **2003** **(ANSI/AWWA C104/A21.4)**.

L. AWWA C105/A21.5 – Polyethylene Encasement for Ductile-Iron Pipe Systems; American Water Works Association; **2005** **(ANSI/AWWA C105/A21.5)**.

M. AWWA C111/A21.11 – Rubber-Gasket Joints for Ductile-Iron Pipe and Fittings; American Water Works Association; **2007** **(ANSI/AWWA C111/A21.11)**.

N. AWWA C151/A21.51 – Ductile-Iron Pipe, Centrifugally Cast, for Water; American Water Works Association; **2009** **(ANSI/AWWA C151/A2151)**.

O. AWWA C500 – Metal-Seated Gate Valves for Water Supply Service; American Water Works Association; **2009**.

P. AWWA C502 – Dry Barrel Fire Hydrants; American Water Works Association; **2005** **(ANSI AWWA C502/C502a)**.

Q. AWWA C504 – Rubber Seated Butterfly Valves; American Water Works Association; **2006**.

R. AWWA C508 – Swing-Check Valves for Waterworks Service, 2in. (50 mm) Through 24 in. (600 mm) NPS; American Water Works Association; **2009 (ANSI/AWWA C508)**.

S. AWWA C509 – Resilient-Seated Gate Valves for Water Supply Service; American Water Works Association; **2009 (ANSI/AWWA C509)**.

T. AWWA C600 – Installation of Ductile-Iron Water Mains and Their Appurtenances; American Water Works Association; **2010 (ANSI/AWWA C600)**.

U. AWWA C606 – Grooved and Shouldered Joints; American Water Works Association; **2006**.

V. AWWA C900 – Polyvinyl Chloride (VC) Pressure Pipe, 4 in. through 12 in. (100mm through 300mm), for Water Service; American Water Works Association; **2008**.

W. AWWA C901 – Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13mm) Through 3 in. (76mm), for Water Distribution; American Water Works Association; **2008**.

X. UL 246 – Hydrants for Fire-Protection Service; Underwriters Laboratories Inc.; **Current Edition Including All Revisions**.

1.04 SUBMITTALS

A. Product Data: Provide data on pipe materials, pipe fittings, valves and accessories.

B. Manufacturer's Certificate: Certify that **products meet or exceed specified requirements**.

C. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.05 QUALITY ASSURANCE

A. Perform Work in accordance with **City of Clovis standard installation requirements**.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

PART 2 PRODUCTS

2.01 WATER PIPE

A. Ductile Iron Pipe: AWWA C151:
   1. Fittings: **Ductile iron, standard thickness**.
   2. Joints: AWWA C111, rubber gasket with rods.
   3. Jackets: **AWWA C105 polyethylene jacket**.

B. Copper Tubing: ASTM B88, Type K, annealed:
   1. Fittings ASME B 16.18, cast copper, or ASME 16.22, wrought copper.
   2. Joints: Compression connection or AWS A5.8, BCuP silver braze.

C. PVC Pipe: **ASTM D1785, Schedule 40**.
   1. Fittings: ASTM C2466, PVD.
   2. Joints: ASTM D2855, solvent weld.

D. PVC Pipe: AWWA C900 Class **100**.
   1. Fittings AWWA C111, cast iron.
   2. Joints ASTM D3139 compression gasket ring.

E. Polyethylene Pipe: **ASTM D3035, for 45 psig pressure rating**.
   1. Fittings: AWWA C901, molded **or fabricated**.
   2. Joints: **Fusion Joints**.

F. Polyethylene Pipe: AWWA C901
   1. Fittings AWWA C901, molded **or fabricated**.
   2. Joints: **Compression**.

G. Trace Wire: Magnetic detectable conductor, **clear plastic covering, imprinted with "Water Service" in large letters**.

2.02 VALVES

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Gate Valves Up to **3 inches**:

   1. Brass or Bronze body, non-rising stem, inside screw, single wedge or disc, **compression ends**, **with control rod**, **post indicator**, **valve key and extension box**.

C. Gate Valves **3 inches and Over**:

   1. AWWA C500, iron body, bronze trim, non-rising stem with square nut, single wedge, **flanged ends, control rod**, **post indicator**, **valve key**, **and extension box**.

   2. AWWA C509, iron body, bronze trim, non-rising stem with square nut, single wedge, resilient seat, **flanged ends**, **control rod**, **post indicator**, **or valve key**, **and extension box**.

D. Ball Valves Up to **2 inches**:

   1. Brass body, Teflon coated brass ball, rubber seats and stem seals, Tee stem-predrilled for control rod, **AWWA inlet end**, **compression outlet with electrical ground connector**, **with control rod**, **valve key**, **and extension box**.

E. Swing Check Valves From **2 inches to 24 inches**:

   1. AWWA C508, iron body, bronze trim, **45 degree swing disc, renewable disc and seat, flanged ends**.

F. Butterfly Valves From 2 inches to 24 inches:

   1. AWWA C504, iron body, bronze disc, resilient replaceable seat, water or lug ends, **ten position lever handle**.

2.03 HYDRANTS

A. Hydrants: Type as required by utility company. (City of Clovis)

B. Hydrant Extensions: Fabricate in multiples of **6 inches** **with rod and coupling to increase barrel length**.

C. Hose and Streamer Connection: Match sizes with utility company, two hose nozzles, **one pumper nozzle**.

D. Finish: **Primer and two coats of enamel** **in color required by utility company**.

2.04 BEDDING AND COVER MATERIALS

A. Bedding: As specified in **Section 31 23 16.13**.

B. Cover: As specified in **Section 31 23 16.13**.

2.05 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type specified in Section **03 30 00**.

B. Backflow Prevention and Water Meter: Type as required by the City of Clovis, Refer to Project plans sheet C300.

C. Manhole and Cover: Refer to Section **33 02 13**.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that building service connection and municipal utility water main size, location, and invert are as indicated.

3.02 PREPARATION

A. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

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

C. Prepare pipe connection to equipment with flanges or unions.

3.03 TRENCHING

A. See the **sections on excavation and fill; section on trenching for additional requirements**.

B. Hand trim excavation for accurate placement of pipe to elevations indicated.

C. Form and place concrete for pipe thrust restraints at each change of pipe direction. Place concrete to permit full access to pipe and pipe accessories.

D. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.04 INSTALLATION – PIPE

A. Maintain separation of water main from **sewer** **piping in accordance with municipal code**.

B. Group piping with other site piping work whenever practical.

C. Establish elevations of buried piping to ensure not less than **3-4 ft** **of cover**.

D. Install pipe to indicated elevation to within tolerance of **5/8 inches**.

E. Install ductile iron piping and fittings to AWWA C600.

F. Install grooved and shouldered pipe joints to AWWA C606.

G. Route pipe in straight line.

H. Install pipe to allow for expansion and contraction without stressing pipe or joints.

I. Install access fittings to permit disinfection of water system performed under Section **33 13 00**.

J. Slope water pipe and position drains at low points.

K. Install trace wire **6 inches** **above top of pipe**, **coordinate with** **Section 31 23 16.13**.

3.05 INSTALLATION – VALVES AND HYDRANTS

A. Set valves on solid bearing.

B. Center and plumb valve box over valve. Set box cover f lush with finished grade.

C. Set hydrants plumb; locate pumper nozzle perpendicular to and facing roadway.

D. Set hydrants to grade, with nozzles at least **20 inches above ground**.

E. Locate control valve **4 inches away from hydrant**.

F. Provide a drainage pit **36 inches square by 24 inches deep filled with 2 inches** washed **gravel. Encase elbow of hydrant in gravel to 6 inches above drain opening. Do not connect drain opening to sewer**.

G. Paint hydrants in accordance with EPCOR Water Company requirements.

3.06 SERVICE CONNECTIONS

A. Provide water service **to utility company requirements with reduced pressure backflow preventer and water meter with by-pass valves and sand strainer**.

B. Provide sleeve in **retaining wall for service main. Support with reinforced concrete bridge. Calk enlarged sleeve watertight**.

C. Anchor service main to interior surface of **foundation wall**.

D. Provide **18 gage galvanized sheet metal sleeve surrounding service main to 6 inches above floor and 6 feet minimum below grade. Size for 2 inches minimum of glass fiber insulation stuffing**.

3.07 FIELD QUALITY CONTROL

A. Perform field inspection **and testing in accordance with City of Clovis standard installation requirements.**

B. Pressure test water piping to **100** psi.

C. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to **the owner.**

END OF SECTION

SECTION 33 31 11 | SITE SANITARY UTILITY SEWERAGE PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Sanitary sewerage drainage piping, fittings, and accessories.

B. Connection of building sanitary drainage system to **municipal sewers**.

1.02 RELATED REQUIREMENTS

A. Section **03 30 00** – **Cast-in-Place Concrete**: **Concrete for base pad construction**.

B. Section **31 23 16** – **Excavation**: **Excavating of trenches**.

C. Section **31 23 16.13** – **Trenching**: **Excavating, bedding, and backfilling**.

D. Section **31 23 23** – **Fill**: **Bedding and backfilling**.

E. Section **33 05 13** – **Manholes and Structures**.

1.03 DEFINITIONS

A. Bedding: Fill placed under, beside, and directly over pipe, prior to subsequent backfill operations.

1.04 REFERENCE STANDARDS

A. ASTM A74 – Standard Specification for Cast Iron Soil Pipe and Fittings; **2009**.

B. ASTM A746 – Standard Specification for Ductile Iron Gravity Sewer Pipe; **2009**.

C. City of Littlefield Standard Specification for Public Works Construction;

D. ASTM C564 – Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings; **2009a**.

E. ASTM D1785 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; **2006**.

F. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications; **2011**.

G. ASTM D2729 – Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings; **2011**.

H. ASTM D3034 – Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings; **2008**.

I. AWWA C111/A21.11 – American National Standard for Rubber Gasket Joints for Cast Iron and Ductile Iron Pressure Pipe and Fittings; **2007**. (**ANSI/AWWA C111/A21.11**)

1.05 SUBMITTALS

A. See Section **01 30 00** – **Administrative Requirements, for submittal procedures**.

B. Product Data: Provide data indicating pipe and pipe accessories.

C. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.

D. Manufacturer's Certificate: Certify that **products meet or exceed specified requirements**.

E. Project Record Documents:

1. Record location of pipe runs, connections, **catch basins**, **cleanouts**, **and invert elevations**.

2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

PART 2 PRODUCTS

2.01 SEWER PIPE MATERIALS

A. Provide products that comply with **applicable codes**.

B. Cast Iron Soil Pipe: ASTM A74, **Service type**, **hub and spigot end**.

C. Joint Seals for Cast Iron Pipe: ASTM C564 rubber gaskets.

D. Ductile Iron Pipe: ASTM A746, **Pressure Class 350 with asphaltic, bell and spigot end**.

E. Joint Seals for Ductile Iron Pipe: AWWA C111/A21.11 rubber gaskets.

F. Plastic Pipe: ASTM D2729, Poly (vinyl Chloride) (PVC) material **bell and spigot style solvent sealed joint end**.

G. Plastic Pipe: ASTM 3034, Type PSM, Poly(Vinyl Chloride) (PVC) material **bell and spigot style solvent sealed joint end**.

H. Plastic Pipe: ASTM D1785, Schedule **40**, **Poly (Vinyl Chloride) (PVC) material bell and spigot style solvent sealed joint end**.

I. Joint Seals: Mechanical lamp ring type, **stainless steel**, **expanding and contracting sleeve**, **neoprene**, or **ribbed gasket for positive seal**.

J. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, cleanouts, reducers, traps and other configurations required.

2.02 PIPE ACCESSORIES

A. Trace Wire: Magnetic detectable conductor, **clear plastic covering, imprinted with "Sewer Service" in large letters**.

2.03 CLEANOUT MANHOLE

A. Lid and Frame: Cast iron construction, hinged lid:

1. Lid Design: **Open checkerboard grill**.
2. Nominal Lid and Frame Size: **26 inches**.

B. Shaft Construction and **Concentric Cone Top Section: Reinforced precast**, **Concrete pipe sections, lipped male/female dry joints, cast steel ladder rungs into shaft sections at 12 inches nominal shaft diameter of 36 inches**.

C. Base Pad: Cast-in-place concrete of type specified in Section **03 30 00**, **leveled top surface to receive concrete shaft sections, sleeved to receive sanitary sewer pipe sections**.

2.04 BEDDING AND COVER MATERIALS

A. Pipe Bedding Material: As specified in **Section 31 23 16.13**.

B. Pipe Cover Material: As specified in **Section 31 23 16.13**.

PART 3 EXECUTION

3.01 GENERAL

A. Perform work in accordance with **applicable code(s)**.

3.02 TRENCHING

A. See **Section 31 23 16.13 for additional requirements**.

B. Hand trim excavation for accurate placement of pipe to elevations indicated.

C. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.03 INSTALLATION – PIPE

A. Verify that **trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings**.

B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions. Seal watertight.

1. Plastic Pipe: Also comply with ASTM D2321.

C. Lay pipe to slope gradients noted on **layout drawings with maximum variation from true slope of 1/8 inch in 10 feet**.

D. Connect to **building sanitary sewer outlet, municipal sewer system, through installed sleeves**.

E. Install trace wire **6 inches above top of pipe, coordinate with Section 31 23 16.13**.

3.04 INSTALLATION – CLEANOUTS

A. Form bottom of excavation clean and smooth to correct elevation.

B. Form and place cast-in-place concrete base pad, with provision for sanitary sewer pipe end sections.

C. Establish elevations and pipe inverts for inlets and outlets as indicated.

D. Mount lid and frame level in grout, secured to top cone section to elevation indicated.

3.05 FIELD QUALITY CONTROL

A. Perform field inspection **and testing as designated by the Owner**.

B. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to **the Owner.**.

3.06 PROTECTION

A. Protect pipe and bedding cover from damage or displacement until backfilling operation is in progress.

END OF SECTION