MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
GROUNDING, BONDING, LIGHTNING PROTECTION AND SURGE PROTECTION FOR ELECTRICAL SYSTEM EQUIPMENT

ITS:EG 1 of 6 APPR:HLO:JVG:10-21-20
FHWA:APPR:10-29-20

a. Description. This work consists of installing functional and unobtrusive grounding and bonding system, lightning protection for all poles and structures that exceed 15 feet in height, and surge protection for all conductors entering or leaving equipment cabinets and in equipment housings at the specified locations shown on the plans.

1. Comply with the *National Fire Protection Association* (*NFPA*) 70 - *National Electrical Code* (*NEC*), latest edition adopted by the State of Michigan.

2. Adhere to *NFPA* 780 - *Lightning Protection Code* as indicated herein.

3. Adhere to *Underwriters Laboratory* (*UL*) listings as indicated throughout this document.

4. Comply with the *National Electrical Safety Code* (*NESC*).

Identify to the Engineer any conflicts between the requirements of regulatory agencies and the contract for this project.

Submit product data for each type of product used (i.e. “shop drawings”) for approval by the Engineer before work commences.

As direct by the Engineer, submit a system plan, locating air terminals, conductor routing, supports, connectors, ground rods, and connection, mounting, and splicing details. Identify where special means will be incorporated to avoid galvanic reactions due to dissimilar metals.

b. Materials. For each component required in the contract, meet the following requirements:

1. Grounding and Bonding.

A. Grounding Electrodes (driven rods). Provide ground rods that are 3/4-inch diameter by 10 feet long, made of copper-clad steel with a minimum of 10 mils copper cladding, complying with *ANSI/UL* 96/96A and *ANSI/NEMA* GR-1.

B. Ground Bus Bar. Provide a ground bar with pressure-type terminals sized per grounding and grounding electrode conductors that will be connected. Furnish a ground bar and mounting hardware appropriate for intended installation (for example, on an equipment rack in a damp location).

C. Grounding Conductors. Unless noted otherwise, ensure below grade conductors

used for bonding grounded systems are bare, stranded #6 American Wire Gauge (AWG) copper conductors, and ensure bonding conductors routed inside enclosures and cabinets are green insulated stranded #6 AWG conductors.

D. Bonding Equipment. Ensure all bonding equipment is UL listed and provide adequate surface area for intended application; ensure bonding equipment being used as part of a lightning protection system are sized in accordance with *NFPA 780*. Ensure enclosure ground lugs are furnished and installed by the enclosure manufacturer.

2. Lightning Protection. Ensure all lightning protection materials are *UL 96* listed for lightning protection, Class II regardless of structure height.

Do not use a combination of materials that may cause electrolytic coupling of such a nature that corrosion is accelerated. This includes copper in direct contact with aluminum and copper in direct contact with galvanized steel in exterior or other wet locations. Ensure two dissimilar metals are not connected unless preventative measures inhibit galvanic corrosion.

3. Surge Protection.

A. Provide protectors that are *UL 497B* listed to protect the data communications cable that meet or exceed the following minimum requirements:

(1) Maximum clamping voltage.

(a) Common-mode. Twice peak signal voltage.

(b) Differential-mode. 50 volts (V) to ground.

(2) Technology. Two-stage using gas discharge tube and metal-oxide varistor or approved equal.

(3) Overcurrent protection. Integral polymeric positive temperature coefficient (PPTC) device.

(4) Maintainability. Replaceable without tools.

(5) Protect microwave vehicle detection system (MVDS) and direct current (DC) power cables with grounded metal oxide varistors of appropriate voltages. Provide devices with surge capacity of at least 3,000 Amperes (A). Ensure surge protection for these devices are in accordance with device manufacturer specific guidelines.

(6) Protect power over Ethernet (POE) devices, with protectors designed for POE applications.

B. Provide protectors that are *IEEE 802.3at* and *International Electrotechnical Commission (IEC) 61643-21* compliant.

C. Incoming Power Service.

(1) ITS Cabinets. Protect 120/240V incoming power service to equipment cabinet with *UL 1449* listed Type 2 devices. They must meet the following requirements:

(a) Terminals. #12 AWG;

(b) Surge Capacity Rating. Minimum 40 kilo ampere (kA)/mode, 80kA/phase;

(c) Voltage Protection Rating. L-N, L-G, N-G. L-N;

(d) Short Circuit Current Rating. 100kA;

(e) Nominal discharge current of 20,000A;

(f) Line protection. L-N, L-G, L-L, and N-G;

(g) Indicators. Light-emitting Diode (LED) status indication;

(h) Compatibility. Compatible with the main circuit breaker ampacity.

(2) Signal Cabinets. Surge Protection for incoming power service for signal cabinets is specified and paid for under 20SP-820Z National Electrical Manufacturers Association Type Traffic Signal Cabinet.

c. Construction. Install equipment, materials, and devices in accordance with equipment manufacturer's written instructions and in compliance with applicable installation standards.

Provide exothermically welded connections below grade and in areas exposed to visible moisture. Ensure permanent mechanical clamp, listed for wet locations, is used in locations where damage to existing cable is possible.

Ensure terminals and connectors are *UL* listed and sized for the conductors that will be used. Use clips, harnesses, or ties in cabinets to keep grounding electrode conductors and bonding conductors out of the way of service activities.

Permanently affix distinct wire numbers or alphanumeric labels to each cable.

1. Grounding and Bonding. Furnish and install insulated and/or bare wire and cables, as indicated on the plans. Ensure

A. Installation.

(1) Bond metallic items, such as poles, towers, horizontal and vertical structures, metal conduit junction boxes, fences, and pad mounted equipment to form a low-impedance ground plane.

(2) Provide equipment grounding conductors and grounding electrode conductors that conform to the *NEC*. Use of metallic conduit to replace grounding conductors is prohibited. Connection of grounding conductor to neutral (grounded) conductor must only occur at service disconnect.

(3) Bond all metallic conduits, boxes, and cabinets to the grounding system. Provide metallic conduit terminations with grounding bushings. Where not otherwise noted ensure all bonding conductors are green stranded insulated #6 AWG.

(4) Bond electrical grounding conductors to lightning protection system grounding conductors.

(5) Drive a grounding electrode through the base of the handholes nearest the electrical racks, poles, and structures to attach to the grounding system as shown on the plans.

B. Testing.

(1) Measure ground grid resistance using 3-point method per *IEEE* 81 with earth ground test meter, ensure meter has been calibrated within manufacturer recommended timeframe. Install additional ground rods and conductors as required and re-measure until resistance to ground is equal to or less than 10 Ohms. Additional ground rods, conductors, conduit, and ancillary materials required to achieve stated resistance are included in pay items below and will not be paid for separately. Test the ground rods and conductors in the presence of the Engineer. Provide documentation to the Engineer of ground grid measurement results for each site location tied to a single grounding system.

(2) Furnish all test equipment required to test the copper cabling in accordance with the parameters specified.

2. Lightning Protection. Install lightning protection system in accordance with the following requirements:

A. Install down conductors, per *NFPA* 780, in a direct path from air terminals to ground connections free of splices and sharp bends; except when the pole is used as the down conductor or where noted on the plans. No bend of a conductor is to form a final angle of more than 90 degrees nor have a bend radius of less than 8 inches.

B. Conceal and protect down conductors and interior wiring from view at all exterior locations above grade as practical. Conceal cable down conductors within structural elements. Cable down conductors must be enclosed within conduit for all installations. Reference the plan details for conduit size. Use conduit or guards to protect the conductor to a point 10 feet above grade or as shown on the plans where down conductors are exposed to environmental hazards at grade level.

C. Secure exposed cable conductors to the structure at intervals not exceeding 3 feet. Use fasteners, nails, screws, straps, or bolts for the intended application and of the same material as the conductor or of electrolytically compatible materials. Galvanized or plated steels are prohibited.

D. Use a grounding electrode for the lightning protection system, located in the dedicated lightning protection handhole(s). Install additional ground rods and conductors as required and re-measure until resistance to ground is equal to or less than 10 Ohms.

E. Bond the lightning protection system to common electrical grounding system as shown on the plans.

F. Install air terminals on concrete spun poles as detailed on the plans. Bond the air

terminal to the cast-in-place down conductor.

G. Dynamic message sign (DMS) structures are capable of acting as a down conductor per *NFPA* 780. Install air terminals into the air terminal bases located on the roof of the sign housing and bond the air terminals to the DMS structure, as shown on the plans.

H. Lane Control System (LCS) structures (Type E Truss or Type E Cantilever) are capable of acting as a down conductor per NFPA 870. Install air terminal on the upper chord and bond the air terminals to the LCS structure, as shown on the plans.

I. Install air terminal on traffic signal strain poles, mast arms, wood poles and truss arms as shown on the plans.

3. Surge Protection.

A. Install the required number and type of modular surge protector devices, as determined by the number and type of incoming lines.

B. Arrange the equipment and cabinet wiring to minimize leader length to surge protector.

C. Avoid sharp bends in leaders to surge protectors.

4. Warranty. Provide all surge protective devices covered by this special provision with a standard manufacturer's warranty, transferable to MDOT. All the surge protective devices must carry a warranty (parts and labor) of 3 years from the date of shipment with at least 2 years of warranty remaining at the start of burn-in. Furnish warranty and other applicable documents from the manufacturer, and a copy of the invoice showing the date of shipment, to the Engineer prior to final written acceptance.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following pay items:

Pay Item **Pay Unit**

Grounding, Bonding, and Surge Protection .....Lump Sum
Lightning Protection, Pole.....Each
Lightning Protection, Structure, Large Dynamic Message Sign .....Each
Lightning Protection, Structure, Small Dynamic Message Sign.....Each
Lightning Protection, Structure, Type E Truss.....Each
Lightning Protection, Structure, Type E Cantilever .....Each

1. **Grounding, Bonding, and Surge Protection** will be measured and paid for as a lump sum for all work to ground each electrical component as described by this special provision and as shown on the plans. Partial payments will be made based as shown below:

Approved Equipment Submittals	50%
Completed Installation	75%
Inspection by State of Michigan Electrician	100%

2. **Lightning Protection, Pole** will be measured and paid for as each lightning protection system provided for protection of equipment on a pole, mast arm or truss arm with Class II materials.

3. **Lightning Protection, Structure, Large Dynamic Message Sign** and **Lightning Protection, Structure, Small Dynamic Message Sign** will be measured and paid for as each lightning protection system provided for protection of a Dynamic Message Sign, using the structure as a down conductor.

4. **Lightning Protection, Structure, Type E Truss** and **Lightning Protection, Structure, Type E Cantilever** will be measured and paid for as each lightning protection system provided for protection of a Lane Control System on a Type E Truss or Type E Cantilever, using the structure as a down conductor.