



Florida Department of Transportation

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ANANTH PRASAD, P.E.
SECRETARY

January 30, 2014

Chad Thompson
Programs Operations Engineer
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: State Specifications and Estimates Office
Section **620**
Proposed Specification: **6200000 Grounding and Lightning Protection.**

Dear Mr. Thompson:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

These changes were proposed by Jeff Morgan to consolidate requirements for grounding and lightning protection into one Section.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to SP965DS or daniel.scheer@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at 414-4130.

Sincerely,

Daniel Scheer, P.E.
State Specifications Engineer

DS/cah
Attachment

cc: Florida Transportation Builders' Assoc.
State Construction Engineer

TRAFFIC CONTROL SIGNAL AND DEVICE INSTALLATION GROUNDING.
(REV ~~11-6-13~~~~12-30~~~~2710-143~~)

SECTION 620
~~TRAFFIC CONTROL SIGNAL AND DEVICE~~
~~INSTALLATION GROUNDING AND LIGHTNING PROTECTION~~

620-1 Description.

Furnish and install grounding and lightning protection to provide personnel and equipment protection against faults, surge currents and lightning transients. Provide a grounding and lightning protection system in accordance with the details shown in the Design Standards unless otherwise shown on the plans. ~~Install grounding for traffic signal and device installations to provide personnel and equipment protection against faults, surge currents and lightning transients.~~

620-2 Materials.

620-2.1 Ground Rods: *Use UL listed ground rods made of copper-clad steel with a nominal diameter of 5/8 inches. Ground rod sections must be a minimum of 8 feet in length and manufactured for the sole purpose of providing electrical grounding.*

620-2.2 Ground Rod Assembly: *Provide a ground rod assembly consisting of one or more ground rods coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.*

620-2.3 Ground Rod Array: *Provide ~~a~~ ground rod arrays, as required, consisting of two or more ground rod assemblies, bonded together and spaced a minimum of 40 feet apart.*

620-2.4 Grounding Conductors: *Use solid copper insulated (green) conductor for electrical or lightning protection ground from the system ground bus or barrier plates to the ~~grounding electrode rod assembly~~. Use either solid or stranded copper insulated (green) conductor for all ground connections. Equipment grounding conductors shall be sized equipment grounding conductors according to the NEC section 250.122. Size ~~Grounding electrode conductors shall be sized according to the NEC section 250.66 (A) through (C).~~ Ground Ring grounding conductors shall be sized according to the NEC section 250.52 (A), (4). Lightning protection main conductors shall be #2 AWG from the ~~air terminals to the ground rods.~~*

620-2.5 Exothermic Grounding Bond: *Make all connections to the ~~grounding electrode rod assemblies~~ using exothermic welds.*

620-2.6 Air Terminals: *Use UL listed air terminals.*

620-2.7 Surge Protective Devices: *Provide Surge Protective Devices (SPDs) to protect electronics from lightning, transient voltage surges, and induced current.*

Install SPDs on all power, data, video and any other conductive circuit. SPD requirements for lighting must meet the minimum requirements of Section 992 and the Design Standards. SPDs for traffic control devices, including ITS equipment, must be listed on the Department's Approved Product List (APL).

Provide primary and secondary surge protection on AC power at traffic control device field sites.

620-2.7.1 SPD for 120V or 120/240V at Power Entry Point: Install a SPD at the utility disconnect to the cabinet. Ensure that the SPD at the utility disconnect includes L-N, L-G, and N-G protection and has a maximum surge current rating of 50 kA per phase or greater. Verify that the SPD has been labeled to indicate that the unit is UL 1449, Third Edition listed.

Ensure an SPD is provided ~~closest termination/disconnection point~~ where the supply circuit enters the ~~ITS device~~-cabinet. Locate the SPD on the load side of the main disconnect and ahead of any and all ~~ITS~~-electronic devices and connected in parallel with the AC supply. ~~Configure the SPD to operate at 120 volt single phase (i.e., line, neutral and ground) or 120/240 volt single phase (line 1, line 2, neutral and ground) as required to match the supply circuit configuration.~~ Ensure that the SPD in the cabinet includes L-N, L-G, and N-G protection and has a maximum surge current rating of ~~is~~ 50 kA per phase or greater. Verify that the SPD has been labeled to indicate that the unit is UL 1449, Third Edition listed.

Ensure that the SPD has a visual indication system that monitors the weakest link in each mode and shows normal operation or failure status and also provides one set of normally open (NO)/normally closed (NC) Form C contacts for remote alarm monitoring. The enclosure for a SPD shall have a NEMA 4 rating.

620-2.7.2 SPD at Point of Use: Install a SPD at the point the ITS devices receive 120 volt power and connected in series with the circuits. Ensure that these devices comply with the minimum functional requirements shown in Table 785-1. Ensure that the units are rated at 15 or 20 amps load and are configured with receptacles.

Ensure that these units have internal fuse protection and provide common mode (L+N-G) protection.

620-2.7.3 SPD for Low-Voltage Power, Control, Data and Signal Systems: Install a specialized SPD on all conductive circuits including, but not limited to, data communication cables, coaxial video cables, and low-voltage power cables. Ensure that these devices comply with the minimum functional requirements shown in Table 620-1 for all available modes (i.e. power L-N, N-G; L-G, data and signal center pin-to-shield, L-L, L-G, and shield-G where appropriate).

Circuit Description	Clamping Voltage	Data Rate	Surge Capacity	Maximum Let-Through Voltage
12 VDC	15-20 V	N/A	5kA per mode (8x20 μ s)	<150 Vpk
24 VAC	30-55 V	N/A	5kA per mode (8x20 μ s)	<175 Vpk
48 VDC	60-85 V	N/A	5kA per mode (8x20 μ s)	<200 Vpk
120 VAC at POU	150-200 V	N/A	20kA per mode (8x20 μ s)	<550 Vpk

<i>Table 620-1</i>				
<i>SPD Minimum Requirements</i>				
<i>Circuit Description</i>	<i>Clamping Voltage</i>	<i>Data Rate</i>	<i>Surge Capacity</i>	<i>Maximum Let-Through Voltage</i>
<i>Coaxial Composite Video</i>	<i>4-8 V</i>	<i>N/A</i>	<i>10kA per mode (8x20 μs)</i>	<i><65 Vpk (8x20 μs/1.2x50μs; 6kV, 3kA)</i>
<i>RS422/RS485</i>	<i>8-15 V</i>	<i>Up to 10 Mbps</i>	<i>10kA per mode (8x20 μs)</i>	<i><30 Vpk</i>
<i>T1</i>	<i>13-30 V</i>	<i>Up to 10 Mbps</i>	<i>10kA per mode (8x20 μs)</i>	<i><30 Vpk</i>
<i>Ethernet Data</i>	<i>7-12 V</i>	<i>Up to 1 Gbps</i>	<i>1kA per mode (10x1000 μs)</i>	<i><30 Vpk</i>
<i>POE</i>	<i>60-70 V</i>	<i>Up to 1 Gbps</i>	<i>5kA per mode (8x20 μs)</i>	<i><200Vpk (100kHz 0.5μs; 6kV, 500A)</i>

Ensure that SPDs are listed and meet the requirements of UL 497B or UL 497C, as applicable.

620-2.7.4 Mechanical Specifications: Ensure equipment is permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number.

All parts must be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

620-2.7.5 Environmental Specifications: Ensure that SPDs operate properly during and after being subjected to the temperature and humidity test profile described in NEMA TS 2, Section 2.2.7, and the vibration and shock tests described in NEMA TS 2, Sections 2.2.8., and 2.2.9.

620-2.7.6 Manufacturer's Warranty: Ensure that the SPD has a manufacturer's warranty covering failures for a minimum of 10 years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

The term "failure" for warranty replacement is defined as follows:

Parallel-connected, power-rated SPD units are considered in failure mode when any of the visual indicators shows failure mode when power is applied to the terminals at the unit's rated voltage, or the properly functioning over-current protective device will not reset after tripping.

Series-connected, low-voltage power, data, or signal units are considered in the failure mode when an open circuit condition is created and no data/signal will pass through the SPD device or a signal lead is permanently connected to ground.

In the event that the SPD, including any component of the unit, should fail during the warranty period, the entire SPD shall be replaced by the manufacturer at no cost to the Department or maintaining agency.

Use ground rods made of copper clad steel with a minimum diameter of 5/8 inches. Ground rod sections must be a minimum of 8 feet in length and manufactured for the sole purpose of providing electrical grounding.

~~620-2.2 Grounding Conductors:~~ Use solid No. 6 AWG copper insulated (green) conductor for electrical or lightning protection ground from the system ground bus or barrier plates to the grounding electrode assembly. Use either solid or stranded No. 6 AWG copper insulated (green) conductor for all ground connections.

~~620-2.3 Exothermic Grounding Bond:~~ Use materials from the same source, meeting the requirements of the Institute of Electrical and Electronics Engineers Standards 80 and 837.

~~620-2.4 Ground Rod Coupling Devices:~~ Use a coupling device for grounding electrode to grounding electrode connections approved by the Engineer.

620-3 *Installation* Requirements for Grounding.

620-3.1 General: *Construct a single-point grounding system. Install the primary ground rod assembly in an electrical pull box so that the top four inches are accessible for inspection, resistance testing, and maintenance. The primary ground rod assembly and electrical pull box shall be installed between 12 inches to 36 inches from the element being grounded. The top of all other grounding electrode rod assemblies connected to the primary grounding electrode rod assembly in an array must shall be buried a minimum of 18 inches below grade. Direct bury grounding conductors used to connect ground rod assemblies a minimum of 18 inches below finished grade.*

Bond all ground rod assemblies and ground rod arrays together with solid bare tinned copper wire unless otherwise shown on the plans. Install grounding conductors in a straight path.

Make all bonds between ground wires and ground rod assemblies and ground rod arrays with an exothermic bond with the following exception: do not exothermically bond sections of ground rods to create the ground rod assembly and do not use exothermically bonds on connections within a cabinet. Apply an anti-oxidant compound to all mechanical connections.

Connect primary surge protection for power at the service entrance or main disconnect. Connect secondary surge protection at point of use, unless otherwise shown in the plans.

Ensure that lightning protection systems conform to the requirements of NFPA 780, Standard for the Installation of Lightning Protection Systems. Install SPDs that have an operating voltage appropriate for the characteristics of the circuits they protect. Meet all local electrical codes which exceed these Specifications. Install all grounding conductors, which bond grounding electrode assemblies, 18 inches below finished grade. Accomplish grounding for any element of a traffic control signal and device installation by installing either a grounding electrode assembly or a grounding electrode array, unless otherwise specified in the Contract Documents.

~~Bond all grounding electrode assemblies and arrays together and place in a location that minimizes the length of the grounding conductor between the assembly or array and the element being grounded.~~

620-3.2 Minimum Grounding Resistance: *Obtain a resistance to ground of 5 Ohms or less for each of the following elements. or i Install multiple ground rod*

assemblies totaling a maximum length of up to 80 feet, as required to achieve minimum grounding resistance.

- a. Power service for traffic control devices
- b. Signal and ITS cabinets
- c. ITS Poles/Structures with electronic equipment
- ~~d. Electronic equipment~~
- de. DMS and DMS structures
- ef. Equipment Shelters and fencing
- fg. Communication Towers

~~Obtain a resistance to ground of 25 Ohms or less for each of the following elements or install multiple~~ Install ~~Aa single ground rod assembly~~ies totaling provides the total ground rod required for these elements ~~20 feet.~~

- a. Conventional lighting
- b. External lighting for signs
- c. Signal cable & span wire
- d. Aerial interconnect messenger wire
- e. Pedestals for pedestrian signals
- f. Pull boxes with metal covers when 120V (or greater) AC power

is present

- g. Splice vaults with wire grounding units

Install a minimum of one primary ground rod assembly ~~as a primary ground rod~~. If a grounding and lightning protection system using a single ground rod assembly does not achieve the required resistance to ground, extend the length of the ground rod assembly an additional 20 feet or install an additional ground rod assembly 40 feet away and connect it to the main ground rod assembly to create a ground rod array. Continue installing ground rod assemblies connected in an array until the required resistance is obtained or until the maximum required total length of ground rod is installed.

Grounding systems formed from horizontally constructed conductive radials are permitted if site conditions prohibit the use of vertically driven rods as permitted by the NEC Article 250.53(G). A grounding system consisting of the maximum total length of ground rod required is acceptable in cases where soil conditions prevent the grounding system from achieving the required resistance to ground. Submit the site resistance measurement to the Engineer. ~~Install 40 feet of ground assembly or array for each of the following elements:~~

- ~~(a) Electric power service~~
- ~~(b) Pole with electrical power service installed~~
- ~~(c) Pole mounted cabinet with electrical power service installed~~
- ~~(d) Controller or detector cabinet~~

~~Install 20 feet of ground assembly or array for each of the following elements:~~

- ~~(a) Pole~~
- ~~(b) Pedestals for pedestrian signals~~
- ~~(c) Metal cover used with pull boxes with AC power~~

~~Ensure that all separately grounded elements at an intersection are bonded together to form an intersection grounding network.~~

————— For span wire assemblies, use the span wire to connect the grounding electrode assemblies or arrays of the poles.

————— Do not install a grounding electrode assembly or array for a base mounted cabinet within 6 feet of a grounding electrode assembly or array installed for a pole.

————— Make all bonds between ground wires and grounding electrode assemblies or arrays with an exothermic bond with the following exception: do not exothermically bond grounding electrode to grounding electrode connections or the system ground bussbar or barrier plate connections located within a cabinet.

————— **620-3.2 Grounding Electrode Assembly:** Provide a grounding electrode assembly consisting of one or more grounding electrodes coupled together, such that the total length of the electrodes in the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.

————— Install the grounding electrode assembly so that the final elevation at the top is 6 inches below finished earth grade. Mark the location of the assembly with a stake and keep uncovered until the Engineer performs a final inspection of the installation.

————— **620-3.3 Grounding Electrode Array:** Provide a grounding electrode array consisting of two or more grounding electrode assemblies, bonded together and spaced a minimum of 6 feet apart.

————— **620-3.4 Grounding Poles:** Ground all poles, including pedestals for pedestrian signals, in accordance with the details for grounding and connections shown in the Design Standards.

————— For non-metallic traffic signal poles, including pedestals for pedestrian signals, accommodate the ground connection from signal heads and span wires to the ground electrode assembly or array located at the pole base in accordance with the details in the Design Standards, Index No. 17727.

————— When erecting new metal poles within 10 feet of existing metal poles or structures, bond the new and existing poles or structures together.

————— **620-3.5 Grounding Electric Power Service:** Ground all electric power services in accordance with the details for grounding and connections shown in the Design Standards, Index No. 17736.

————— **620-3.6 Grounding Controller or Detector Cabinets:** Ground controller or detector cabinets to the bussbar located in the cabinet. Place the grounding electrode assembly or array as close to the cabinet as possible.

————— **620-3.7 Grounding Span Wire Mounted Signal Heads and Electrically Powered Signs:** Ground span wire mounted signal heads and electrically powered signs through the span wire assembly in accordance with the details shown in the Design Standards, Index No. 17727.

————— Do not use guy wires for grounding purposes, however bond any guy wire to the span wire as part of the intersection grounding network.

620-3.3 Grounding Traffic Control Systems at Signalized Intersections: Ensure that all separately grounded elements at an intersection (signal cabinet, power service, mast arms or strain poles, etc.) are bonded together to form an intersection grounding network array.

For traffic signal poles, including pedestals for pedestrian signals, accommodate the ground connection from signal heads and electrically powered signs

through span wires to the ground rod assembly or array located at the pole base in accordance with the details in the Design Standards.

For span wire assemblies, use the span wire to connect the ground rod assemblies or arrays of the poles. Do not use guy wires for grounding purposes, however bond any guy wire to the span wire as part of the intersection grounding network.

620-3.4 Grounding Traffic Control Systems on Highways: *Install the primary ground rod assembly at the base of the traffic control device supporting structure. Bond all metal components of the system (such as cabinets, steel poles, and concrete pole grounding wire) to the grounding system using a mechanical connection on the equipment side and an exothermically welded connection at the down cable. Do not use split bolts for grounding system connections.*

Connect all ground rod assemblies and any associated grounded electrical system within a 100-foot radius (but not beyond the edge of the roadway) of the primary ground rod assembly. Connect the primary ground rod assembly to a single point main grounding bar inside the equipment cabinet or mounted it to the base of the traffic control device supporting structure unless otherwise shown on the plans.

Place multiple grounding rod assemblies, as required, in an ground rod array as depicted in the Design Standards unless otherwise shown on the plans. If a required array cannot be placed in the right-of-way, submit an alternate placement detail for approval.

620-3.5 Grounding Highway Lighting Systems: *Ground each metal light pole.*

For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods 20 feet in length.

Ground all high mast poles in accordance with the details for grounding in the Design Standards, Index No. 17502.

620-3.6 Grounding Equipment Shelters: *Install all grounds for the equipment shelter on the side of the building that utilities, communication cables, and fiber enter. Connect all earth grounds to this point, including the grounding system for ~~the surge protection devices~~ (SPDs). Make all connections to SPDs according to the manufacturer's recommendations.*

Ensure that communication cables, AC power, emergency generator, and equipment frames are connected by the shortest practical route to the grounding system. Protect the lead lengths from each device to the SPD.

Use compression type connection for all interior connections to bond grounding conductors to equipment in the shelter. For connections to bus bars, use mechanical connections having two bolts on a double-lug connector. Install star washers, or another means that accommodates the fasteners used and ~~to~~ achieves reliable electrical connections that will not deteriorate. Crimp and solder all wires connected to lugs or clamps. Verify electrical continuity of all connections. Remove all non-conducting surface coatings before each connection is made.

Ensure that ground conductors are downward coursing, vertical, and as short and straight as possible. Ensure that the minimum bending radius for interior equipment shelter grounds is 8 inches. Avoid sharp bends and multiple bends in grounding conductors.

620-3.6.1 Interior Grounding: Install a No. 2 AWG solid bare copper wire approximately 1 foot below the ceiling on each wall and mount it using insulated standoffs. Ensure that the wire encircles the equipment room, forming a ring or continuous loop ~~along the upper interior perimeter ground, and includes the wall area above the door.~~ Mechanically connect the cable trays to the ~~upper~~ interior perimeter ground using stranded copper wires with green insulation and bolted terminal connectors at the cable tray ends. Make all points where cable tray sections meet electrically continuous by use of a short jumper wire with terminals attached at each end.

Directly bond all other metallic objects, such as door frames and doors, air conditioners, alarm systems, wall-mounted communication equipment, etc., to the closest interior perimeter ground with the shortest possible stranded copper wire with green insulation. Bond the door to the doorframe using flexible welding cable.

620-3.6.2 Exterior Grounding: Install an exterior grounding system consisting of multiple ground rods assemblies around the exterior perimeter of the equipment shelter. ~~to achieve the resistance to ground required in 620-3.2~~ Place the ground rods assemblies a minimum of 2 feet from the building foundation in a suitable access point. Bond the following items to the shelter's grounding system ~~using No. 2 AWG solid bare tinned copper wire:~~

1. Metal building parts ~~not grounded by the internal grounding rings,~~ such as downspouts and siding.
2. Ground rods provided by power or telephone utilities for grounding of AC power or surge protection devices, as permitted by local codes.
3. Shelter support skids, bases, or foundations, if applicable.
4. Any metal object larger than 4 square feet.
5. External metal fencing.

620-3.6.3 Punch Block SPD Grounding: ~~Ground For all Type 66 punchdown blocks, install No. 2 AWG solid bare tinned copper wire to ground external line surge protection devices. Install the No. 2 AWG solid bare tinned copper wire in accordance with the SPD manufacturer's recommendations and mechanically connect them to the shelter's interior perimeter ground.~~

620-3.6.4. Equipment Shelter Fence Grounding: Ensure that the metal Type B fence is grounded to fence perimeter grounding conductors ~~wires~~ consisting of No. 2 AWG solid bare tinned copper wires that encircle the entire compound to achieve required resistance to ground required in 620-3.2.

Exothermically bond any splices in the grounding conductors ~~wire~~. Bury the fence perimeter grounding conductor ~~wire~~ a minimum of 2.5 feet below finished grade. Bond all fence posts to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Bond the gate and gatepost together with a flexible ground, such as welding cable wires. Ground the gatepost to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Exothermically bond all connections to the fence perimeter ground wire.

Connect the fence's top rail to each corner post and in the middle of each side. Ground the fence fabric with No. 2 AWG solid bare tinned copper wire connected to the fence posts. Connect the fence perimeter wires to the ground rod

assemblies of the equipment shelter's ground system with No. 2 AWG solid bare tinned copper wire, as shown in the plans.

Ensure that all ground leads are No. 2 AWG solid bare tinned copper wires for all above- and underground grounding wire installations. Ensure that all exothermic bonds are appropriate for the application. Do not use welding or other forms of bonding without prior written approval.

620-4 Ground Resistance Testing and Inspection.

620-4.1 Testing: *Measure the ground resistance with an instrument designed specifically to measure and document earth/ground resistance, soil resistivity, and current flow. Conduct the test by using the fall-of-potential method as described in the IEEE Standard 81. If fall-of-potential tests cannot be performed, it is acceptable to measure resistance at each accessible ground rod using a clamp-on ground resistance tester. Provide the Engineer with written, certified test results for each testing location. Illegible hand-written results are not acceptable. Provide the following information on the test results:*

- _____ 1. The formal name or ID for the location where the test was performed*
- _____ 2. The GPS latitude and longitude for the location where the test was performed*
- _____ 3. The date on which the test was performed*
- _____ 4. The make and model number, serial number, and last date of calibration (by an independent testing facility within the previous 12 months) for the grounding resistance testing device used*
- _____ 5. Contact information (including name, signature, and employer name) for each person conducting, witnessing, or certifying the test*
- _____ 6. Description of the local environmental and soil conditions at the time of testing*
- _____ 7. A rough sketch of the site grounding system; along with the corresponding measured data points*
- _____ 8. Page numbering showing the current page number and total page count (e.g., Page 1 of 3)*

620-4.2 Inspection: *Do not backfill below-grade grounding installations and grounding connections until inspected and approved. The Engineer will inspect the installation for proper connection types, tightness, workmanship, and conformance to plans. Replace any exothermic bonds that are deemed unsatisfactory with new exothermic bonds. Repair or replace any mechanical connections that are deemed unsatisfactory. Measure the resistance at each accessible ground rod using a clamp-on earth tester. The measurement at any individual rod is the cumulative resistance of all rods in a parallel circuit.*

For grounding system inspections, notify the Engineer at least five days prior to completion of the installation. Record all test results in a standardized format approved by the Engineer prior to testing. All recorded test report data shall be dated, witnessed, and signed by at least one representative of the Department and the Contractor. Remedy all deficiencies at no cost to the Department.

620-54 Basis of Payment.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

**TRAFFIC CONTROL SIGNAL AND DEVICE INSTALLATION GROUNDING.
(REV 1-30-14)**

**SECTION 620
GROUNDING AND LIGHTNING PROTECTION**

620-1 Description.

Furnish and install grounding and lightning protection to provide personnel and equipment protection against faults, surge currents and lightning transients. Provide a grounding and lightning protection system in accordance with the details shown in the Design Standards unless otherwise shown on the plans.

620-2 Materials.

620-2.1 Ground Rods: Use UL listed ground rods made of copper-clad steel with a nominal diameter of 5/8 inches. Ground rod sections must be a minimum of 8 feet in length and manufactured for the sole purpose of providing electrical grounding.

620-2.2 Ground Rod Assembly: Provide a ground rod assembly consisting of one or more ground rods coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.

620-2.3 Ground Rod Array: Provide ground rod arrays, as required, consisting of two or more ground rod assemblies, bonded together and spaced a minimum of 40 feet apart.

620-2.4 Grounding Conductors: Use solid copper insulated (green) conductor for electrical or lightning protection ground from the system ground bus or barrier plates to the ground rod assembly. Size equipment grounding conductors according to the NEC section 250.122. Size grounding electrode conductors according to the NEC section 250.66.

620-2.5 Exothermic Grounding Bond: Make all connections to the ground rod assemblies using exothermic welds.

620-2.6 Air Terminals: Use UL listed air terminals.

620-2.7 Surge Protective Devices: Provide Surge Protective Devices (SPDs) to protect electronics from lightning, transient voltage surges, and induced current.

Install SPDs on all power, data, video and any other conductive circuit. SPD requirements for lighting must meet the minimum requirements of Section 992 and the Design Standards. SPDs for traffic control devices, including ITS equipment, must be listed on the Department's Approved Product List (APL).

Provide primary and secondary surge protection on AC power at traffic control device field sites.

620-2.7.1 SPD for 120V or 120/240V Power: Install a SPD at the utility disconnect to the cabinet. Ensure that the SPD at the utility disconnect includes L-N, L-G, and N-G protection and has a maximum surge current rating of 50 kA per phase or greater. Verify that the SPD has been labeled to indicate that the unit is UL 1449, Third Edition listed.

Ensure an SPD is provided where the supply circuit enters the cabinet. Locate the SPD on the load side of the main disconnect and ahead of any and all

electronic devices and connected in parallel with the AC supply. Ensure that the SPD in the cabinet includes L-N, L-G, and N-G protection and has a maximum surge current rating of 50 kA per phase or greater. Verify that the SPD has been labeled to indicate that the unit is UL 1449, Third Edition listed.

Ensure that the SPD has a visual indication system that monitors the weakest link in each mode and shows normal operation or failure status and also provides one set of normally open (NO)/normally closed (NC) Form C contacts for remote alarm monitoring. The enclosure for a SPD shall have a NEMA 4 rating.

620-2.7.2 SPD at Point of Use: Install a SPD at the point the ITS devices receive 120 volt power and connected in series with the circuits. Ensure that these devices comply with the minimum functional requirements shown in Table 1. Ensure that the units are rated at 15 or 20 amps load and are configured with receptacles.

Ensure that these units have internal fuse protection and provide common mode (L+N-G) protection.

620-2.7.3 SPD for Low-Voltage Power, Control, Data and Signal Systems: Install a specialized SPD on all conductive circuits including, but not limited to, data communication cables, coaxial video cables, and low-voltage power cables. Ensure that these devices comply with the minimum functional requirements shown in Table 1 for all available modes (i.e. power L-N, N-G; L-G, data and signal center pin-to-shield, L-L, L-G, and shield-G where appropriate).

Circuit Description	Clamping Voltage	Data Rate	Surge Capacity	Maximum Let-Through Voltage
12 VDC	15-20 V	N/A	5kA per mode (8x20 μ s)	<150 Vpk
24 VAC	30-55 V	N/A	5kA per mode (8x20 μ s)	<175 Vpk
48 VDC	60-85 V	N/A	5kA per mode (8x20 μ s)	<200 Vpk
120 VAC at POU	150-200 V	N/A	20kA per mode (8x20 μ s)	<550 Vpk
Coaxial Composite Video	4-8 V	N/A	10kA per mode (8x20 μ s)	<65 Vpk (8x20 μ s/1.2x50 μ s; 6kV, 3kA)
RS422/RS485	8-15 V	Up to 10 Mbps	10kA per mode (8x20 μ s)	<30 Vpk
T1	13-30 V	Up to 10 Mbps	10kA per mode (8x20 μ s)	<30 Vpk

Table 1				
SPD Minimum Requirements				
Circuit Description	Clamping Voltage	Data Rate	Surge Capacity	Maximum Let-Through Voltage
Ethernet Data	7-12 V	Up to 1 Gbps	1kA per mode (10x1000 μ s)	<30 Vpk
POE	60-70 V	Up to 1 Gbps	5kA per mode (8x20 μ s)	<200Vpk (100kHz 0.5 μ s; 6kV, 500A)

Ensure that SPDs are listed and meet the requirements of UL 497B or UL 497C, as applicable.

620-2.7.4 Mechanical Specifications: Ensure equipment is permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number.

All parts must be made of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal.

620-2.7.5 Environmental Specifications: Ensure that SPDs operate properly during and after being subjected to the temperature and humidity test described in NEMA TS 2, Section 2.2.7, and the vibration and shock tests described in NEMA TS 2, Sections 2.2.8., and 2.2.9.

620-2.7.6 Manufacturer's Warranty: Ensure that the SPD has a manufacturer's warranty covering failures for a minimum of 10 years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

The term "failure" for warranty replacement is defined as follows:

Parallel-connected, power-rated SPD units are considered in failure mode when any of the visual indicators shows failure mode when power is applied to the terminals at the unit's rated voltage, or the properly functioning over-current protective device will not reset after tripping.

Series-connected, low-voltage power, data, or signal units are considered in the failure mode when an open circuit condition is created and no data/signal will pass through the SPD device or a signal lead is permanently connected to ground.

In the event that the SPD, including any component of the unit, should fail during the warranty period, the entire SPD shall be replaced by the manufacturer at no cost to the Department or maintaining agency.

620-3 Installation.

620-3.1 General: Construct a single-point grounding system. Install the primary ground rod assembly in an electrical pull box so that the top four inches are accessible for inspection, resistance testing, and maintenance. The primary ground rod assembly and electrical pull box shall be installed between 12 inches to 36 inches from the element being grounded. The top of all other ground rod assemblies connected to the primary ground rod assembly in an array must be buried a minimum of 18 inches below grade. Direct bury grounding conductors used to connect ground rod assemblies a minimum of 18 inches below finished grade.

Bond all ground rod assemblies and ground rod arrays together with solid bare tinned copper wire unless otherwise shown on the plans. Install grounding conductors in a straight path.

Make all bonds between ground wires and ground rod assemblies and ground rod arrays with an exothermic bond with the following exception: do not exothermically bond sections of ground rods to create the ground rod assembly and do not exothermically bond connections within a cabinet. Apply an anti-oxidant compound to all mechanical connections.

Connect primary surge protection for power at the service entrance or main disconnect. Connect secondary surge protection at point of use, unless otherwise shown in the plans.

Ensure that lightning protection systems conform to the requirements of NFPA 780, Standard for the Installation of Lightning Protection Systems. Install SPDs that have an operating voltage appropriate for the characteristics of the circuits they protect.

620-3.2 Minimum Grounding Resistance: Obtain a resistance to ground of 5 Ohms or less for the following elements. Install multiple ground rod assemblies totaling a maximum length of up to 80 feet, as required to achieve minimum grounding resistance.

- a. Power service for traffic control devices
- b. Signal and ITS cabinets
- c. ITS Poles/Structures with electronic equipment
- d. DMS and DMS structures
- e. Equipment Shelters and fencing
- f. Communication Towers

Install a single ground rod assembly for these elements.

- a. Conventional lighting
- b. External lighting for signs
- c. Signal cable & span wire
- d. Aerial interconnect messenger wire
- e. Pedestals for pedestrian signals
- f. Pull boxes with metal covers when 120V (or greater) AC power

is present

- g. Splice vaults with wire grounding units

Install a minimum of one primary ground rod assembly. If a grounding and lightning protection system using a single ground rod assembly does not achieve the required resistance to ground, extend the length of the ground rod assembly an additional 20 feet or install an additional ground rod assembly 40 feet away and connect it to the main ground rod assembly to create a ground rod array. Continue installing ground rod assemblies connected in an array until the required resistance is obtained or until the maximum required total length of ground rod is installed.

Grounding systems formed from horizontally constructed conductive radials are permitted if site conditions prohibit the use of vertically driven rods as permitted by the NEC Article 250.53(G). A grounding system consisting of the maximum total length of ground rod required is acceptable in cases where soil conditions prevent

the grounding system from achieving the required resistance to ground. Submit the site resistance measurement to the Engineer.

620-3.3 Grounding Traffic Control Systems at Signalized Intersections:

Ensure that all separately grounded elements at an intersection (signal cabinet, power service, mast arms or strain poles, etc.) are bonded together to form an intersection grounding network array.

For traffic signal poles, including pedestals for pedestrian signals, accommodate the ground connection from signal heads and electrically powered signs through span wires to the ground rod assembly or array located at the pole base in accordance with the details in the Design Standards.

For span wire assemblies, use the span wire to connect the ground rod assemblies or arrays of the poles. Do not use guy wires for grounding purposes, however bond any guy wire to the span wire as part of the intersection grounding network.

620-3.4 Grounding Traffic Control Systems on Highways: Install the primary ground rod assembly at the base of the traffic control device supporting structure. Bond all metal components of the system (such as cabinets, steel poles, and concrete pole grounding wire) to the grounding system using a mechanical connection on the equipment side and an exothermically welded connection at the down cable. Do not use split bolts for grounding system connections.

Connect all ground rod assemblies and any associated grounded electrical system within a 100-foot radius (but not beyond the edge of the roadway) of the primary ground rod assembly. Connect the primary ground rod assembly to a single point main grounding bar inside the equipment cabinet or mount it to the base of the traffic control device supporting structure unless otherwise shown on the plans.

Place multiple ground rod assemblies, as required, in a ground rod array as depicted in the Design Standards unless otherwise shown on the plans. If a required array cannot be placed in the right-of-way, submit an alternate placement detail for approval.

620-3.5 Grounding Highway Lighting Systems: Ground each metal light pole.

For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods 20 feet in length.

Ground all high mast poles in accordance with the details for grounding in the Design Standards, Index No. 17502.

620-3.6 Grounding Equipment Shelters: Install all grounds for the equipment shelter on the side of the building that utilities, communication cables, and fiber enter. Connect all earth grounds to this point, including the grounding system for SPDs. Make all connections to SPDs according to the manufacturer's recommendations.

Ensure that communication cables, AC power, emergency generator, and equipment frames are connected by the shortest practical route to the grounding system. Protect the lead lengths from each device to the SPD.

Use compression type connection for all interior connections to bond grounding conductors to equipment in the shelter. For connections to bus bars, use mechanical connections having two bolts on a double-lug connector. Install star washers, or another means that accommodates the fasteners used and achieves reliable electrical connections that will not deteriorate. Crimp and solder all wires connected to lugs or

clamps. Verify electrical continuity of all connections. Remove all non-conducting surface coatings before each connection is made.

Ensure that ground conductors are downward coursing, vertical, and as short and straight as possible. Ensure that the minimum bending radius for interior equipment shelter grounds is 8 inches. Avoid sharp bends and multiple bends in grounding conductors.

620-3.6.1 Interior Grounding: Install a No. 2 AWG solid bare copper wire approximately 1 foot below the ceiling on each wall and mount it using insulated standoffs. Ensure that the wire encircles the equipment room, forming a ring or continuous loop. Mechanically connect the cable trays to the interior perimeter ground using stranded copper wires with green insulation and bolted terminal connectors at the cable tray ends. Make all points where cable tray sections meet electrically continuous by use of a short jumper wire with terminals attached at each end.

Directly bond all other metallic objects, such as door frames and doors, air conditioners, alarm systems, wall-mounted communication equipment, etc., to the closest interior perimeter ground with the shortest possible stranded copper wire with green insulation. Bond the door to the doorframe using flexible welding cable.

620-3.6.2 Exterior Grounding: Install an exterior grounding system consisting of multiple ground rod assemblies around the exterior perimeter of the equipment shelter. Place the ground rod assemblies a minimum of 2 feet from the building foundation in a suitable access point. Bond the following items to the shelter's grounding system:

1. Metal building parts such as downspouts and siding.
2. Ground rods provided by power or telephone utilities for grounding of AC power or surge protection devices, as permitted by local codes.
3. Shelter support skids, bases, or foundations, if applicable.
4. Any metal object larger than 4 square feet.
5. External metal fencing.

620-3.6.3 Punch Block SPD Grounding: Ground Type 66 punchdown blocks in accordance with the manufacturer's recommendations and mechanically connect them to the shelter's interior perimeter ground.

620-3.6.4. Equipment Shelter Fence Grounding: Ensure that the metal Type B fence is grounded to fence perimeter grounding conductors consisting of No. 2 AWG solid bare tinned copper wires that encircle the entire compound to achieve required resistance to ground required in 620-3.2.

Exothermically bond any splices in the grounding conductors. Bury the fence perimeter grounding conductor a minimum of 2.5 feet below finished grade. Bond all fence posts to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Bond the gate and gatepost together with a flexible ground, such as welding cable wires. Ground the gatepost to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Exothermically bond all connections to the fence perimeter ground wire.

Connect the fence's top rail to each corner post and in the middle of each side. Ground the fence fabric with No. 2 AWG solid bare tinned copper wire connected to the fence posts. Connect the fence perimeter wires to the ground rod

assemblies of the equipment shelter's ground system with No. 2 AWG solid bare tinned copper wire, as shown in the plans.

Ensure that all ground leads are No. 2 AWG solid bare tinned copper wires for all above- and underground grounding wire installations. Ensure that all exothermic bonds are appropriate for the application. Do not use welding or other forms of bonding without prior written approval.

620-4 Ground Resistance Testing and Inspection.

620-4.1 Testing: Measure the ground resistance with an instrument designed specifically to measure and document earth/ground resistance, soil resistivity, and current flow. Conduct the test by using the fall-of-potential method as described in the IEEE Standard 81. If fall-of-potential tests cannot be performed, it is acceptable to measure resistance at each accessible ground rod using a clamp-on ground resistance tester. Provide the Engineer with written, certified test results for each testing location. Illegible hand-written results are not acceptable. Provide the following information on the test results:

1. The formal name or ID for the location where the test was performed
2. The GPS latitude and longitude for the location where the test was performed
3. The date on which the test was performed
4. The make and model number, serial number, and last date of calibration (by an independent testing facility within the previous 12 months) for the grounding resistance testing device used
5. Contact information (including name, signature, and employer name) for each person conducting, witnessing, or certifying the test
6. Description of the local environmental and soil conditions at the time of testing
7. A rough sketch of the site grounding system; along with the corresponding measured data points
8. Page numbering showing the current page number and total page count (e.g., Page 1 of 3)

620-4.2 Inspection: Do not backfill below-grade grounding installations and grounding connections until inspected and approved. The Engineer will inspect the installation for proper connection types, tightness, workmanship, and conformance to plans. Replace any exothermic bonds that are deemed unsatisfactory with new exothermic bonds. Repair or replace any mechanical connections that are deemed unsatisfactory. Measure the resistance at each accessible ground rod using a clamp-on earth tester. The measurement at any individual rod is the cumulative resistance of all rods in a parallel circuit.

For grounding system inspections, notify the Engineer at least five days prior to completion of the installation. Record all test results in a standardized format approved by the Engineer prior to testing. All recorded test report data shall be dated, witnessed, and signed by at least one representative of the Department and the Contractor. Remedy all deficiencies at no cost to the Department.

620-5 Basis of Payment.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.