SECTION 700

TRAFFIC CONTROL DEVICES

I. GENERAL

1.1 DESCRIPTION

These specifications cover general construction items, methods, and procedures common to traffic control devices. Installation of materials shall be accomplished in accordance with the manufacturer's instructions except when otherwise indicated.

1.2 MATERIALS

A. Concrete shall be Class A3 conforming to the requirements of VDOT Section 217.

B. Reinforcing steel shall conform to the requirements of VDOT Section 223.

C. Paint shall conform to the requirements of VDOT Section 231 and shall be applied in accordance with the requirements of VDOT Section 411 except on nonferrous materials where it shall be applied in accordance with the requirements of the manufacturer's recommendations.

D. Galvanizing shall conform to the requirements of VDOT Section 233.

E. Electrical items shall conform to the requirements of VDOT Section 238.

F. Wood for posts and poles shall conform to the requirements of VDOT Section 236 and shall be treated in accordance with the requirements of VDOT Section 236. Wood items shall be cut prior to treatment.

G. Steel for fabricated items shall conform to the requirements of VDOT Section 226 and shall be fabricated, welded and inspected in accordance with the requirements of VDOT Section 407.

H. Aluminum for fabricated items shall conform to the requirements of VDOT Section 229 and shall be fabricated, welded and inspected in accordance with the requirements of VDOT Section 407.

I. Poles, posts, and overhead and bridge-mounted sign structures shall conform to the following:

1. Conventional and offset lighting poles shall be steel or aluminum.

2. Overhead and bridge mounted sign structures, signal poles and high-mast lighting poles shall be steel.

3. Pedestal poles with a nominal diameter of more than 2 inches shall be steel aluminum. Pedestal poles 2 inches and less in nominal diameter shall conform to the requirements of VDOT Section 238 for metal conduit.

4. Sign posts shall be wood or steel.

Lighting, signal, and pedestal poles; sign posts; and overhead and bridge-mounted sign structures not designed to support variable message signs shall conform to the requirements of the 1994 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

Overhead and bridge-mounted sign structures, including "butterfly" structures, designed to support variable message signs shall conform to the requirements of the 2001 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the following clarifications:

- Basic wind speed shall be used in the designs. The alternate method for wind pressures provided in Appendix C shall not be used.

- When the installation location of the structures lies between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.

- Any optional design parameters indicated in the AASHTO specification that are "allowed when acceptable to the Owner" shall not be used for the designs.

Steel poles, posts, and overhead and bridge-mounted sign structures shall be hot-dip galvanized after fabrication. Except when shop painting is required, steel poles and posts shall be given one shop coat of primer and two field coats of paint and the galvanization finish of overhead and bridge-mounted sign structures shall be field treated for paint retention and two coats of paint applied.

Signal, lighting, and pedestal poles shall be of a one-piece or sectional single unit, tubular form, and shall be round or multisided. Multisided poles shall have at least eight sides. Pole shafts and arms shall have a removable cap fastened by at least three screws.

Mast arms shall not deflect below the horizontal plane or exceed a rise of 3 percent of the arm length after loads are applied. Mast arm poles shall include an arm attachment flange plate continuously welded to the gusset and side plates. The gusset and side plates shall be continuously welded to the pole and each other. The flange shall be fabricated with four studs permanently attached for receiving nuts (attaching arm). The flange plate and pole shall have a 2 1/2-inch wiring hole with a grommet centered in the pattern.

Strain poles shall not exceed a dead load deflection of 3 percent of the distance between the base of pole and point of dead load attachment. The minimum bottom diameter of strain poles shall be 11 inches.

Signal poles shall have a steel "J" hook located inside the poles for wire suspension within 5 inches of the top.

Lighting, signal poles, and overhead structures shall have a grounding lug welded to the inside of the pole or structure easily accessible from the hand hole. The grounding lug shall be designed to secure the grounding electrode conductor and equipment-grounding conductor by inserting the conductor under a setscrew type of lug.

Signal poles, high-mast lighting poles, and overhead sign structures, including butterfly structures, shall have a minimum of six anchor bolts, each having a minimum diameter of 1 1/2 inch. The maximum space between the bottom of the base plate and the top of the foundation shall be no greater than the diameter of the anchor bolt plus 1 inch.

No grout will be permitted between the base plate and the top of the foundation of overhead structures, mast arm, lighting, and signal poles. No lock nuts or split washers will be allowed with the anchor bolts.

J. Anchor bolts shall be steel, conforming to the requirements of VDOT Section 226.02(c)2. The portion of anchor bolts beginning 4 inches below the top of the foundation and extending above the foundation shall be galvanized except when stainless steel is used.

Anchor bolts used with signal poles, high-mast lighting poles, and overhead sign structures, including butterfly structures, shall conform to the requirements of VDOT Section 517 of the 2001 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

K. Breakaway support systems shall conform to the requirements of the 1994 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

1. Breakaway couplers and skirt covers shall be aluminum. Threaded studs, nuts, and washers shall be stainless steel or galvanized steel.

2. Frangible bases shall be aluminum.

3. Slip bases shall be galvanized steel or other approved noncorrosive metal.

L. Miscellaneous hardware shall be brass, bronze, stainless steel, or galvanized steel.

1.3 WORKING DRAWINGS

The Contractor shall submit to the Owner working drawings, including design calculations and catalog cuts, in accordance with the requirements of VDOT Section 105.

In lieu of working drawings and catalog cuts, the Contractor may submit a letter indicating the brands, types, and models, of equipment along with the approval numbers and contract item numbers. The Contractor shall include the words "Testing Required" with the approval numbers when materials testing is required for the equipment. The approval numbers shall be taken from VDOT's

preapproved traffic control device lists. Inclusion of equipment on this list does not ensure acceptance if contract requirements prohibit use of the equipment.

II. EXECUTION

A. Ground Rods: Grounding electrodes (rods) shall be installed in accordance with the requirements of the NEC or by other methods approved by the Owner. Grounding electrodes shall be installed using a hydraulic/pneumatic/electric hammer drill driving device with an electrode drive bit to minimize damage to the electrode tip. The electrode drive bit shall be designed for 3/4-inch electrodes. Grounding electrodes shall include a grounding electrode conductor and grounding electrode clamp.

1. Electrical service grounding electrode installations: The following procedures apply only to installing electrical service grounding electrodes:

- Grounding electrodes and grounding electrode conductors shall be installed in the presence of the Owner at a date and time mutually agreed upon.

- Grounding electrode and grounding electrode conductors shall be connected using exothermic welds. Exothermic welds shall be designed for the size conductor and grounding electrodes and shall be installed in accordance with the manufacturer's instructions. Grounding electrode conductors and grounding electrodes shall be cleaned to remove oxidation and any other foreign material from the surface before performing the exothermic welds.

- Primary grounding electrodes shall not have a resistance to ground of more than 25 ohms. 10-foot section of grounding electrode shall have a minimum of an 8-foot contact with soil. Grounding electrodes shall be spaced a minimum of 10 feet between all electrodes.

- Primary grounding electrodes shall be installed vertically to a depth of 40 feet or until refusal. If the vertical grounding electrode cannot be installed to a minimum of an 8-foot contact with soil, the Contractor shall install a grounding electrode at an angle of no more than 45 degrees to a depth of 40 feet or until refusal. If refusal occurs prior to installing the electrode to a minimum of an 8-foot contact with soil, the Contractor shall remove the electrode or cut it off 6 inches below grade and abandon it.

- Primary grounding electrodes complying with these requirements shall be augmented with an additional grounding electrode and connected in parallel to the primary grounding electrode to form a system. The augmented electrode shall be a single electrode driven to a depth of 4 inches below the finished grade. If refusal occurs prior to installing the electrode to a minimum of an 8-foot contact with soil, Contractor shall remove the electrode or cut it off 6 inches below grade and abandon it.

- Grounding electrodes shall be coupled at each section with couplers or exothermic welded splices. The grounding electrode conductor shall be

installed to a depth of 18 inches below grade when connecting the primary electrode and augmented grounding electrodes.

- The Contractor shall install a JB-2C junction box at the primary grounding electrode location for access to the electrode for connection and testing. Grounding electrode conductors shall be installed under the bottom flange of the JB-2C. The grounding electrode shall be centered in the bottom of the JB-2C with a minimum of 6 inches exposed. The JB-2C cover shall have the letters "ELEC" cast in the depression on the top.

The Contractor shall notify the Owner of those location(s) where primary grounding electrodes do not conform to the following:

- Resistance does not measure 25 ohms or less.
- Grounding electrode does not have at least an 8-foot contact with soil.

For such locations, the Owner will advise the Contractor how to proceed.

2. Grounding electrode testing: Primary grounding electrodes shall be tested after each 10-foot grounding electrode and/or section thereof is installed using the fall of potential (three-point measurement) method. After the primary grounding electrode is installed and tested, the Contractor shall connect to the augmented electrode(s) to conduct a system test. The Contractor shall disconnect the grounding electrode conductor from the service equipment ground bus and bonding bushing before testing the grounding electrodes/system. The Contractor shall test the grounding electrode as required by the manufacturer's instructions for the type of earth testing equipment. The Contractor shall record the readings on a form provided by the Owner. The completed form shall be signed and submitted to the Owner after installation of the electrical service grounding.

B. Excavation for Foundations: Excavation shall be performed in accordance with the requirements of VDOT Section 401.

C. Concrete Foundations**:** Concrete foundations shall be constructed and cured in accordance with the requirements of VDOT Section 404 and shall rest on material that will adequately support the design load. The Contractor may secure the anchor bolts to prevent their movement during concrete placement with a No. 3 or smaller rebar. Rebar shall be attached to the anchor bolts with rebar twist ties. Exposed areas of concrete foundations shall be given a Class 7 finish in accordance with the requirements of VDOT Section 404. Items shall not be erected on concrete foundations until concrete has cured for at least 28 days or has obtained a compressive design strength of at least 3,000 pounds per square inch.

Foundations for overhead sign structures shall be spread footings unless inadequate soil conditions require deep foundation systems, i.e., drilled piers, driven piles. Drilled foundations may be permitted except for single-pole structures, i.e., overhead single-pole-in-end forms, cantilever, or butterfly.

Foundation designs for signal poles, high-mast lighting poles, and overhead sign structures shall be furnished by the Contractor. Designs shall indicate the cubic yard quantity of

concrete required for the foundations. Foundations shall be designed to conform to the requirements of the same edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* used for the structure it is supporting. The Contractor shall accomplish at least one test bore, as approved by the Owner, at each foundation location to determine the subsurface conditions prior to designing the foundation. Test bores shall be performed in accordance with any of the following three methods:

1. ASTM D 420, ASTM D 1452, and ASTM D 1586
2. ASTM D 3441
3. ASTM D 4719.

The depth of the test borings shall be at least 30 feet. Soil conditions shall be tested at the ground level and then at depth intervals of 3 feet in accordance with any of the three methods stated.

Boring logs shall be properly identified to the actual site with the centerline station and the distance perpendicular from the centerline indicated. On projects where the roadway is existing and no centerline is being surveyed, alternate methods for identifying the location shall be submitted by the Contractor for the Owner's records. Bore log data shall be submitted electronically in an approved format, in accordance with Owner's requirements and the resulting borehole log shall be included with the shop drawing submittals for the foundation designs.

The quantity of cubic yards of concrete that is indicated in the contract is an approximation. Payment will be made for the actual cubic yards of concrete based upon the foundation design supplied by the Contractor.

Test bores shall be performed within 5 feet of the foundation's location, as shown on the plans, or as directed by the Owner.

D. Electrical Service: Electrical service shall be installed in accordance with the requirements of NEC and the local power company. Meter bases and current transformer cabinets will be furnished by the local power company. The Contractor shall make arrangements with the local power for pickup of this equipment. The Owner will request and pay for electrical service and temporary electrical service for items temporarily relocated or adjusted for the purpose of traffic control shown on the plans or directed by the Owner. If the Contractor desires temporary service for his convenience, he shall arrange and pay for the service.

E. Poles, Posts, and Sign Structures: The location of each pole, post, and sign structure will be established by the Contractor with a stake bearing the number of identification designated on the plans. The Owner, accompanied by the Contractor, will inspect the locations and advise the Contractor of any necessary adjustments. Poles, posts, and sign structures shall be made plumb after installation of loads by the use of nuts and flat washers above and below the base plate on each anchor bolt or by other approved methods.

If a pole, overhead sign structure, or span wire is to be located within 10 feet of an electric power line as measured in any direction the Contractor shall immediately inform the Owner.

The Contractor shall not install the equipment until the Owner has reviewed and advised the Contractor of any relocation or to proceed with Work.

A noncorrosive metal identification tag shall be permanently attached approximately 30 inches above the foundation to each signal, pedestal, and lighting pole; overhead sign structure; bridge-mounted sign structure; and steel sign post except U-channel sign posts and square tube steel. The tag shall be of sufficient size for 1/4-inch lettering, single-spaced between lines, and shall be attached by noncorrosive screws or rivets.

The tag shall be imprinted with the locality's name. The tag shall also be imprinted with the following:

1. Manufacturer's name on all tags.
2. Manufacturer's unique ID number on all tags.
3. Date of manufacture on all tags.
4. Signal poles: gage and length of pole and mast arms (s).
5. Pedestal poles: gage and length of pole.
6. Lighting poles: gage and length of pole and luminaire arm (s); electrical phase circuit designation.
7. Overhead sign structures: gage and length of pole and span.
8. Steel sign posts: I-beams: length, size, and weight per foot of post

When transformer bases are used, bolt covers shall be installed on pole anchor bolts. Bolt covers shall be designated to allow ventilation of the nut and anchor bolt.

Poles shall be provided with hand holes that face away from traffic. Hand holes shall be at least 3 by 5 inches and provided with a gasket and cover with an 18-inch-long galvanized chain with a minimum breaking strength of 300 pounds welded to the inside of the pole at the bottom of the hand hole opening and to the inside of the cover to prevent accidental loss.. The cover shall be attached to the pole with noncorrosive cap screws, and attachment holes shall be drilled and tapped.

When required by the plans, the Contractor shall supply a terminal strip consisting of 24 double-pole terminals. The terminal strip shall be constructed of noncorrosive materials and shall be located on the outside of the pole just above the hand hole. A continuously welded frame and a removable, weatherproof, gasketed cover designed to enclose both the hand hole and terminal strip shall be provided.

F. Breakaway Support Systems: Breakaway support systems shall be installed on lighting poles when required by the plans and on pedestal poles except when used for power service. Breakaway support systems shall be installed in accordance with the requirements of the manufacturer's recommendations.

G. Conductor Cables: Conductor cables in conduit runs more than 100 feet in length shall be installed with the use of an approved lubricant or pulling compound. Cleaning agents and

lubricants that have a deleterious effect on cable coverings shall not be used.

Aerial cables that extend more than 20 feet shall be supported by a span wire or reinforced with a copper-clad, galvanized, or stainless steel were for self-support. Cable rings shall be used to attach conductor cables to the supporting wire; however, lash wire may be used to attach interconnect cable when no other conductor cables are attached to the same span wire. Vinyl tape shall be used as shown on the plans to prevent sag. When aerial cables enter a service entrance head, an 8-inch drip loop shall be formed.

Bends in single or multiple conductor cables shall have a bend radius of at least 5 times the outside diameter of the cable.

Conductor cables shall be installed with the slack length coiled in junction boxes. The coiled length shall be sufficient to allow cables to extend at least 2 feet above junction boxes.

Solderless terminals shall not be used for connecting conductor cables having solid conductors to terminal posts.

Splices in lighting conductor cables will be permitted only at accessible locations. Splices in service entrance conductor cable will be permitted only for connection to the utility company's service conductor cables. Splices will not be permitted in signal and interconnect conductor cables.

Splices in lighting and service entrance conductor cables shall be made in accordance with the requirements of the NEC and the following additions and exceptions. Conductor insulation shall be removed only to the amount necessary to install the connector. Exposed conductors shall be wire brushed and cleaned before splicing. Splices shall be made with properly sized non-insulated butt-end connector compression sleeves for single conductors or split bolts for branch circuit connections. Conductor connections shall be made mechanically and electrically secure. Crimping tools used on compression sleeves shall be designed for the application and sized to the splicing connectors. Splices shall be covered with an insulation rated equal to or higher than the voltage rating of the conductor cable. Single and branch circuit conductor splices shall be properly re-insulated and made water resistant by one of the following methods:

- Two layers of rubber electrical tape shall be applied half-lapped with the first layer extending the length of the disturbed insulation and the second layer extending at least 1 inch onto clean undisturbed insulation of each conductor. Rubber electrical tape shall be stretched and wrapped tightly to eliminate air gaps. Rubber electrical tape shall be molded around irregular shapes and multiple conductors for smooth insulation buildup. Over the rubber electrical tape, at least two layers of vinyl electrical tape shall be applied half-lapped with each layer overlapping the end of the proceeding layer by at least 1 inch onto clean, undisturbed insulation. The splice and at least 1 inch of adjacent clean insulation shall be covered using an acceptable water-resistant sealing compound for electrical splices;

- Heat-shrink tubing properly sized shall be installed extending at least 3 inches onto each end of clean, undisturbed insulation. End seams around two or more adjacent conductors shall be sealed and made water resistant; or

- The splice kit shall be properly sized to extend at least 3 inches onto each end of clean, undisturbed insulation.

Single conductor splices within a multi-conductor cable shall be re-insulated using heatshrink tubing.

Re-jacketing of multi-conductor cables shall be accomplished using heat-shrink tubing properly sized.

Heat-shrink tubing shall be heated using a non-contact flameless device or a flamed heat source device equipped with a shield to prevent the flame from coming in contact with the tubing.

Breakaway connectors shall be installed on luminaire conductors and on signal conductors for signal head assemblies on pedestal poles. Breakaway connectors shall be fused for the hot conductors and nonfused for the grounded conductor. Breakaway connectors shall be located in the hand hole of the pole.

Signal and interconnect cable terminal strips shall be sealed with a moisture block compound to prevent moisture from entering the open cable end. The compound shall be soft, pliable, and easily removable and shall be used in accordance with the requirements of the manufacturer's recommendations.

Termination of interconnect cable will be allowed only in a master controller cabinet, local controller cabinet, or terminal enclosure. The cable shield shall be grounded at each termination point. Whenever the cable is entered for connection to equipment, each wire of the cable shall be connected to a terminal post position.

The Contractor shall conduct a Megger test on the installed interconnect cable and shield, for which a reading of 100M ohms shall be required. Testing for 300-volt cable shall be performed at 200 volts, and testing for 600-volt cable shall be performed at 500 volts. Cables shall be disconnected from controller cabinet terminals during testing.

Service entrance and lighting conductor cables shall be marked in accordance with the requirements of Article 310-11 of NEC. Markings shall be continuous and permanent. Signal and interconnect conductor cables shall be marked in accordance with the requirements of the applicable IMSA specification.

Prior to energizing an electrical system, the Contractor shall demonstrate to the Owner that the system is clear and free from short circuits, open circuits, and unintentional grounds. Faulty circuits shall be repaired or replaced by the Contractor at his expense.

1. Electrical service and lighting conductor identification:

   Grounded conductors: Insulated grounded conductors (Neutrals) shall be identified by a continuous white or gray outer finish except that those larger than No. 6 AWG may be identified by three continuous white stripes on other than green insulation along its entire length.

Equipment grounding conductors: Equipment grounding conductors shall be bare, covered, or insulated. Covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes. Ungrounded conductors:

Ungrounded conductors, whether used as a single conductor or in multiconductor cables, shall be finished to be clearly distinguishable from grounded, grounding, and equipment grounding conductors. Ungrounded conductors shall be identified by a continuous color-coding outer finish by phase and system except that those larger than No. 6 AWG may be identified only at readily accessible locations by marking tape, tagging, or other approved means in accordance with NEC requirements.

Color-coding shall be as follows:

Circuit Designation	**Color Code**
2-wire circuits, 120 volts; 3-wire circuits, 120/240 volts; 3-phase, 4-wire wye circuits, 208/120 volts; and 3-phase, 4-wire delta circuits, 240 volts	
Phase A or Line A	Black
Phase B or Line B	Red or Orange*
Phase C	Blue
Grounded Conductor (Neutral)	White or Grey** (see exception above)
Equipment Grounding Conductor	Bare, green, or green with one/more yellow stripes
3-phase, 4-wire wye circuits, 480/277 volts; 3-phase, 3-wire delta circuts, 480 volts	
Phase A	Phase A
Phase B	Phase B
Phase C	Phase C
Grounded Conductor (Neutral)	Grounded Conductor (Neutral)
Equipment Grounding Conductor	Equipment Grounding Conductor
*For 3-phase, 4-wire delta systems, Phase B shall be the high leg and shall be orange. **For outer covering of conductors of different systems that is contained within the same enclosure, refer to Article 200 of the NEC.	

Electrical service and lighting conductors shall be permanently identified in accessible locations (hand holes, transformer bases, junction boxes, control centers, etc.) with non-ferrous metal tags or nylon tags attached to the conductor. Identifications shall be stamped or engraved on the metal tags and lettered with permanent ink on the nylon tags. Identifications shall be legible and shall indicate the electrical phase. Lighting conductors shall also indicate the electrical phase circuit

designation. When the conductors are within a multi-conductor cable, the tag shall be attached to the cable jacket and shall indicate the required information for all conductors on one tag. If the conductors of a multi-conductor cable have been exposed for splicing, connections, etc., the conductors shall be tagged in lieu of the cable jacket.

2. Signal and interconnect cable shall be permanently identified by integral-impregnated color coding. Color-coding for signal cable shall be as follows:

Cable Jacket Color	14/12 Cable	14/7 Cable	14/4 Cable	14/3 Cable
Red	Red	Red	Red	Don't Walk
Orange	Yellow	Yellow		
Green	Green	Green	Green	
Red w/black tracer	Red			
Orange w/black tracer	Yellow			
Green w/black tracer	Green			
Blue	Green	Green		
White w/black tracer	Yellow	Yellow		
Black	Red	Red	Yellow	Walk
Black w/white tracer	Sparer			
Blue w/ black tracer	Spare			
White	AC Ground	AC Ground	AC Ground	AC Ground

Signal and interconnect conductor cable jackets shall be permanently identified in the controller cabinet, junction boxes, hand holes, and other accessible locations. Signal conductor cable shall also be identified in the hand hole of poles if the cables are attached to terminal strips in the hand hole. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and letters with permanent ink on the nylon tags. Identifications shall be legible and shall conform to the following:

a. Signal cable: phase and location of signal head; e.g., 01 NB left-turn head; 01 NB inside left-turn head; 02 SB through-lane heads; 01 left-turn and 06 through-lane heads; 02 Ped head NW Quad

b. Interconnect cable: description and direction from location (if cable is a spare). The word "spare" shall be included after "inter." The direction from location is required only in the controller cabinet, e.g., Inter. NB; Inter. Spare NB; Inter. WB; Inter.

H. Conduit Systems: Conduit systems shall be rigid except where contract documents specify otherwise. PVC, fiberglass, and metal conduit runs shall have the minimum number of couplings permitted by the use of standard conduit lengths. Ends of conduit sections that must be field cut shall be reamed smooth. PE conduit shall be installed in continuous unspliced runs between enclosures. Field-threaded portions of metal conduit shall be galvanized. Except for expansion couplings, conduit sections shall be connected with couplings so that ends will abut squarely inside couplings.

Joint sealing solvent shall be used as recommended by the conduit manufacturer. Where necessary, ends of each length of nonmetallic conduit shall be tapered by machining to provide joints that are tight after assembly.

Conduits shall be continuous and watertight between outlets. Deformed conduit shall not be used. Conduits shall be free from kinks or defects that would cause damage to conductor cables when pulled. Conduits shall be installed so that moisture will drain properly to electrical junction boxes or drainage tees with drip spouts.

After installation, each conduit shall be tested in the presence of Owner for obstructions. A suitable rigid or flexible mandrel having a diameter at least 80 percent of the inside diameter of the conduit shall be pulled through each conduit run. Obstructions shall be removed, and the conduit repaired at the Contractor's expense.

After testing, individual conduit runs more than 150 feet in length that are to remain empty shall be equipped with a nylon or polypropylene pull rope having a tensile strength of at least 1,100 pounds and less than 15 percent elongation at yield.. Twelve inches of pull tapee shall be doubled back into the conduit at each end.

Metallic conduit runs more than 150 feet in length that are to remain empty shall be equipped with either a pull rope or tape having a tensile strength of at least 1,100 pounds. Twelve inches of pull tape or rope shall be doubled back into the conduit at each end.

Open ends of unused conduit shall be closed with watertight plugs, caps, or other seal fittings to seal them against moisture. Open ends of conduits with conductors installed shall be sealed with an approved soft, pliable, and easily removable waterproof sealant. The sealant shall not have a deleterious effect on cable coverings.

Metal conduit systems shall be bonded. When a nonmetallic conduit system is used, the Contractor shall furnish and install a grounding conductor wire to maintain a bonded system in accordance with the requirements of NEC.

Non-metallic conduit with non-metallic cable (fiber optic) within shall be equipped with a No. 8 locator wire.

Wherever conduit crosses a structural expansion joint, conduit shall be provided with an expansion fitting. The fitting shall permit longitudinal movement of the amount specified on the plans.

1. Exposed conduit systems shall be fabricated of heavy wall PVC, fiberglass, or metal, with not more than four bends between any two outlets. The angular sum shall be not more than 360 degrees. When heavy-wall PVC or fiberglass conduit is

accessible to public contact, it shall be covered with a protective shield, conforming to the requirement of VDOT Section 238, for a distance of at least 8 feet above the adjacent finished grade. Splice boxes or pull boxes shall be of a size that will allow proper termination of conduit and connection conductor cables as required by NEC. Conduit shall be terminated by means of approved fittings or bushings.

2. Buried conduit systems shall be installed in straight lines between outlets. When obstructions are encountered during installation and conduit cannot be economically located elsewhere, the obstruction shall be bypassed by offsetting the conduit line in accordance with the requirements of the standard drawings. Required conduit bends shall be installed with a bend radius of at least 5 feet. Conduit bends in structures and foundations shall be installed in accordance with the requirements of NEC. The use of a pipe tee or vice for bending conduit will not be permitted.

   When conduit is to be installed under an existing roadway and open cutting is not permitted, conduit shall be installed by an approved directional boring method. Conduit for the directional boring method shall be PVC designed specifically for the directional boring operation or high-density PE. With the approval of the Owner, the Contractor may elect to use the jacked method to install a pipe sleeve for installation of the required conduit at no additional cost to the Owner.

   Open cut areas shall be backfilled in accordance with the requirements of VDOT Section 302.

I. Junction Box Covers: If a special tool or wrench is needed to remove a cover, the Contractor shall furnish the Owner five such tools.

J. Hydraulic Cement Concrete Sidewalk**:** When disturbed by the installation of equipment, sidewalk shall be replaced in accordance with the requirements of Section 502 along existing joint lines.

III. MEASUREMENT FOR PAYMENT

A. Concrete foundations will be measured in units of each or cubic yards of concrete as indicated on the Bid form. When paid for in cubic yards of concrete, no payment will be made for concrete in excess of the cubic yards of concrete required by the foundation design unless otherwise approved by the Owner. This price shall include foundation design, concrete, reinforcing steel, stub poles, anchor bolts, bolt circle templates, grounding equipment, conduits, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

B. Electrical service will be measured in units of each and will be paid for the contract unit price per each. This price shall include service poles, safety switches or breaker boxes, service entrance conductor cables from the utility company's service box conductor to the safety switch and circuit breaker box, conduit and fittings on poles an steel supports, conduit straps or clamps, meter bases, service entrance heads, thimbleye bolts, steel supports, wireway, junction boxes for grounding electrodes and utility service, excavation, concrete, and pickup and installation of meter base and current transformer cabinet.

C. Luminaire arms will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole mounting brackets, fittings, and mounting hardware. These prices shall also include providing the required finish.

D. Lighting poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include This price shall include pole shafts, luminaire arms, grounding lugs, hand holes and covers, caps, identification tags, anchor bases, bolt covers, bracket arms, and breakaway support systems.. These prices shall also include providing the required finish.

E. Signal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole shafts, mast arms, grounding lugs, hand holes, and covers, caps, fittings, anchor bases, bolt covers, and identification tags. These prices shall also include providing the required finish.

F. Overhead and bridge-mounted sign structures will be measured in units of each will be paid for at the contract unit price per each. This price shall include structural units and supports, hand holes and covers, grounding lugs, walkways and handrails, electrical systems including conduit and fittings, identification tags. These prices shall also include providing the required finish.

G. Sign posts will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include clamps, identification tags, and breakaway base assemblies.

H. Pedestal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include caps, breakaway support systems, hand holes and covers, grounding lugs, identification tags, and anchor bases and bolt covers. These prices shall also include providing the required finish.

I. Wood poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include thimbleye bolts, guy wires with guards and anchors, excavating, backfilling, compacting, disposing or surplus and unsuitable material, and restoring existing areas.

J. Conductor cables will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include conductors, breakaway connections, markings and identifications; splice kits, electrical tape, testing, and connections.

K. Conduit will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include conduit bodies, fittings, bonding systems, pull ropes, plastic spacers, No. 8 locator wire when required, pull or splice boxes with an area of 512 cubic inches or less, supports, and protective metal shields.

L. Trench excavation will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include trenching, encasing, backfilling, locator tape, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

M. Junction boxes will be measured in units of each and will be paid for at the contract unit price per each. This price shall include concrete collars, frames and covers, tools to remove the cover, ground rods, ground conductors, grounding lugs, knockouts, cable racks,

aggregate, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas. These prices shall also include providing the required finish.

N. Test bores will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the test bore, rock sampling, and determination of the soil and rock condition.

O. Electrical service grounding electrode will be measured in units of each, per 10-foot electrode or portion thereof, and will be paid for at the contract unit price per each. This price shall include testing, exothermic welds, grounding electrode(s), electrode couplers, grounding conductor, and report documentation.

P. Bored conduit will be measured in units of linear feet and will be paid for at the contract unit price per linear foot for the size specified. The price shall include conduit; fittings; couplings; and, when required, No. 8 locator wire, bonding systems, and pull rope or tape.

End of Section