

Appendix A

Specifications

The following contact numbers may be used to obtain pavement marking specifications for the respective state:

Maryland	800-637-1290	Ask for Specification Team
New Jersey	609-530-2001	
Pennsylvania	717-787-3620	
Virginia	804-786-1898	
West Virginia	304-558-3063	

VDOT – SPECIFICATIONS (*)

VDOT ROAD AND BRIDGE SPECIFICATION STRUCTURE	A-2 – A-3
SECTION 234 Glass Beads for Reflectorizing Traffic Markings.....	A-4
SECTION 235 Retroreflectors.....	A-4 – A-6
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* Consult the current or applicable *VDOT Road and Bridge Specification Book* and Special Provisions for the most current specifications.

Specification Structure

The Virginia Department of Transportation (VDOT) publishes a book of specifications, called the Road and Bridge Specifications. This book is divided into several Divisions dealing with various contractual matters.

It is of utmost importance that the Contractor and the Inspector/Engineer have the ability to interpret the Road and Bridge Specifications as well as other contract documents.

Division I - General Provisions

Division I deals with the general provisions of the contract, i.e, items which have a general application to all the contract provisions. Items which are covered in this Division include such matters as related to: **Definitions, Bidding Requirements and Conditions, Award and Execution of Contracts, Scope of Work, Control of Work, Control of Material, Legal Relations and Responsibility to the Public, Prosecution and Progress of Work, Measurement and Payment and other Miscellaneous Provisions.**

Hierarchy of Contract Documents

Listed in descending order of precedence they are:

1. Special Provision Copied Notes
2. Special Provisions
3. Plans
4. Road & Bridge Specifications

Plans are generally job specific. Special Provisions and Special Provision Copied Notes are used to add new specifications during the interim between publication of a new Road & Bridge Specification Book. They also are used to correct errors that may have occurred in the previous publication. Special Provision Copied Notes, commonly called “Copied Notes” override all other specifications, plans and special provisions. All applicable Special Provisions and Special Provision Copied Notes are included in the contract.

Division II - Materials

This is where the specifications are listed for all the pavement marking materials. VDOT uses many types of materials to construct pavement markings. Division II tells us what the composition is for the material we are going to use.

Division V - Incidental Construction

Section 512 deals with the types of materials used to **maintain traffic** through construction work zones -- the what, when and where of material usage.

Section 512 also specifies that the American Traffic Safety Services Association’s (ATSSA) publication entitled: “Quality Standards for Work Zone Traffic Control Devices” be used to determine correction and replacement of ineffective devices. This includes pavement markings and markers.

The use of **temporary pavement markers** with construction work zone markings is also described in Section 512.

Division VII - Traffic Control Devices

Section 704 deals with the type of final pavement line markings that are to be used, the what, when and where of material usage. In addition, Table VII-1 in Section 704.03 defines the materials by category or type.

For specification purposes, VDOT categorizes pavement marking materials by **TYPE** and **CLASS**. The “Type” refers to whether the marking will be durable, non-durable, temporary or removable.

Type A - Consists of Traffic Marking Paints. Paint markings are considered **non-durable** markings.

Type B - Marking materials are sub-divided into six (6) classes based on what the materials consist of. Markings constructed from these materials are considered **durable** markings.

Type D and **Type F** - These are Construction Zone marking materials.

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

234.01—DESCRIPTION.

This specification covers glass beads for application on liquid traffic marking materials so as to produce a reflective surface.

234.02—DETAIL REQUIREMENTS.

Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. Glass beads shall be spherical in shape and shall conform to AASHTO M247 Type 1, except that at least 80 percent of the beads shall be round when tested in accordance with the requirements of ASTM D 1155 Procedure B. Beads shall be essentially free of sharp angular particles, milkiness and surface scoring or scratching.

SECTION 235—RETROREFLECTORS

235.01—DESCRIPTION

Retro-reflectors shall consist of a housing/backing with a retro-reflective surface on the front and back, if applicable.

Retro-reflectors for delineators and pavement markers, except temporary markers, shall be molded of methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3.

Retro-reflectors for temporary pavement markers shall have a surface consisting of reflective sheeting or a plastic prismatic element. The housing/backing for temporary pavement markers shall be constructed of methyl methacrylate plastic conforming to the requirements of Federal Specification L-P-380, Type I, Class 3.

Retro-reflectors for delineators shall be the same color as the adjacent pavement marking. Retro-reflectors for pavement markers shall be the same color as the adjacent pavement marking except the backside shall be as follows:

- (a) **One-Way Markers:** The backside shall be red for white raised and white snow plowable raised pavement markers. The backside shall be blank for recessed, temporary pavement markers and yellow raised and yellow snow plowable raised pavement markers.
- (b) **Two-Way Markers:** The backside shall match the adjacent pavement marking, except on recessed markers which shall be blank.

235.02—Detail Requirements.

- (a) **Steel castings for snow plowable pavement markers** shall conform to ASTM A536, hardened to 52-54 RC and shall weigh approximately 5½ pounds. Keels shall be parallel, approximately 0.70 inch thick by 1.90 inch in depth and shall have notched edges. The forward and rear noses of the casting shall be shaped to deflect snowplow blades. Castings shall retain their hardness after removal of adhesives and other foreign residues or shall be capable of conforming to the specified hardness with additional heat treating to ensure recyclability of the castings.
- (b) **Plastic panels for delineators** shall be at least 0.080 inch thick, have a minimum tensile strength at yield of 5000 pounds per square inch when tested in accordance with ASTM D638, and have minimum impact strengths of 2.0 foot-pounds per inch of notch at -20°F and 14.0 foot-pounds per inch of notch at 73°F when tested in accordance with ASTM D256, Method A. The panels shall be flexible and able to recoil, to within 5° of vertical after impact. Panels shall not deteriorate when exposed to the following:
 - 1. Ultraviolet rays
 - 2. Ozone
 - 3. Exhaust fumes
 - 4. Petroleum products
 - 5. Deicing salts
 - 6. Herbicides
- (c) **Aluminum panels for delineators** shall be at least 0.064 inch thick conforming to ASTM B-209, alloy 5052.
- (d) **Delineators** shall have the retro-reflective surface and the housing/backing fused to form a homogenous unit sealed against dust, water and vapor. Retro-reflectors shall show no change in shape or color when subjected to four hours in a circulating air oven at 170° to 180°F. The adhesion system shall be as recommended by the manufacturer.

The specific intensity shall not be less than the values below:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		Clear	Yellow
0°	0.1°	119	71
20°	0.1°	47	28

- (e) **Raised, Recessed and Snow Plowable Raised Pavement Markers** shall have a retro-reflective surface area of no less than 1.4 square inches and the slope of the reflective surfaces shall be no less than 30° nor more than 33° when measured from the pavement surface. The reflective surface shall be protected with a bonded glass face or coated with a clear acrylic compound that utilizes an ultraviolet inhibitor.

The specific intensity shall not be less than the values below when tested in accordance with VTM-70:

Raised and Recessed Pavement Markers				
Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	3.0	1.8	0.75
20°	0.2°	1.2	0.72	0.25

Snow Plowable Raised Pavement Markers				
Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	4.0	2.4	1.0
20°	0.2°	1.6	0.96	0.4

The crushing strength shall be not less than 4,000 pounds when tested in accordance with VTM-71.

Raised and recessed pavement markers shall be at least 4 inches and not more than 4.75 inches in width and not more than 0.55 inch in height.

Retro-reflectors for snow plowable raised pavement markers shall be installed in steel castings conforming to (a) herein and shall have a nominal width of 4 inches excluding the castings.

- (f) Temporary pavement marker shall have a retro-reflective surface of no less than 1.0 square inch. The specific intensity shall not be less than the values below:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		White	Yellow
0°	0.2°	3.0	1.8
20°	0.2°	1.2	0.72

SECTION 246—PAVEMENT MARKING

246.01—DESCRIPTION.

These specifications cover material for use in the various retroreflective pavement-marking applications.

246.02—Detail Requirements.

Materials that must be heated for application shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature.

Materials shall withstand air and roadway temperature variations from 0 degrees F to 140 degrees F without deforming, bleeding, staining, or discoloring and shall maintain their original dimensions and placement without chipping, spalling, or cracking. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, or other ice control materials; oil in the pavement material; or oil and gasoline drippings from vehicles.

- (a) **White and Yellow Pavement Marking Material:** White pavement marking material shall be equal to Federal Standard Color No. 595-17886, and yellow pavement marking material shall be equal to Federal Standard Color No. 595-33538.

Color determination will be made for markings and the diffuse daytime color of the markings shall conform to the below CIE Chromaticity coordinate limits. Color determination for liquid marking materials will be made without drop on beads at least twenty-four (24) hours after application. Color determination for thermoplastic will be made in accordance with the requirements of AASHTO T 250.

Cie Chromaticity Coordinate Limits (Initial without drop-on beads)

Color	1		2		3		4		Daytime Luminance Factor Y (%)	
	X	Y	X	Y	X	Y	X	Y	Min.	Max.
White (Types A; B - Classes I, II & III; & F)	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	80.0	---
Yellow (Types A; B – Classes II & III; & F – except thermoplastic)	0.493	0.473	0.518	0.464	0.486	0.428	0.469	0.452	50.0	60.0
Yellow (Types B – Class I; & F - if thermoplastic)	0.499	0.466	0.545	0.455	0.518	0.432	0.485	0.454	40.0	60.0

Color readings will be determined in accordance with the requirements of ASTM E1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.

Retained daytime color of markings shall conform to the following CIE Chromaticity coordinate limits when measured on a beaded marking after a period of ninety days for construction pavement markings and one year for all other markings:

Cie Chromaticity Coordinate Limits (Retained)								
	1		2		3		4	
Color	X	Y	X	Y	X	Y	X	Y
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375
Yellow	0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400

Retained color readings will be determined using a 0 degrees /45 degrees Hunter Labminiscan Spectro-Colorimeter or equal in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65

Initial nighttime color of yellow thermoplastic and yellow epoxy pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with VTM 111.

CIE CHROMATICITY COORDINATE LIMITS (INITIAL WITH DROP-ON BEADS)								
	1		2		3		4	
Color	X	Y	X	Y	X	Y	X	Y
Yellow	0.486	0.439	0.520	0.480	0.560	0.440	0.498	0.426

The marking material shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24 Table 1 except that barium sulfate is allowed. Total heavy metal levels, with the exception of barium sulfate, shall not exceed 20 times the specified regulatory limits.

The amount and type of yellow pigment and inert filler for yellow material shall be at the option of the manufacturer provided the material complies with all other requirements of this specification.

- (b) **Paint Pavement Marking Material (Type A):** Paint material shall be a fast drying water based, nonleaded, acrylic resin paint suitable for use on both asphalt and hydraulic cement concrete surfaces. Paint shall be selected from the Department's approved list. Paint products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways.

Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.

1. **Hiding Power:** Paint shall show a dry hiding quality that will give a contrast ratio of at least 0.96 at 0.38 mm (15 mil) wet film thickness.
 2. **Settling Properties:** Settling shall be no less than a rating of 8 when tested in accordance with ASTM D869.
 3. **Freeze-Thaw and Heat Stability:** Paint shall show no coagulation or change in viscosity greater than +/- 5 KU.
 4. **Water Resistance:** Paint shall show no blistering, peeling or wrinkling, softening or loss of adhesion.
 5. **VOC: The Volatile Organic Compound** content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.
 6. **Flash Point:** Paint shall have a flash point of at least 140 degrees F when tested in accordance with ASTM D93, Pensky-Martens Closed Cup.
 7. **No-Track Time:** Paint shall have a 60-second maximum vehicle no-track time when measured in accordance with the NTPEP Field Test Procedures.
 8. **Maintained Retroreflectivity and Durability:** Maintained retroreflectivity and durability shall conform to the following requirements after being installed on the test deck for 1 year:
 - a. **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least either 150 for 15 meter or 100 for 30 meter when measured in the skipline or centerline areas.
 - b. **Durability:** Paint shall have a durability rating of at least 4 when determined in the wheel path area.
- (c) **Thermoplastic Pavement Marking Material (Type B, Class D):** Thermoplastic material shall be suitable for use on asphalt concrete surfaces and yellow thermoplastic shall be selected from the Department's approved list. Yellow thermoplastic products will be included on the approved list after the Department determines conformance to the specifications. Thermoplastic material shall have the pigment, beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

1. Composition:

Component	White	Yellow
(Percent by Weight)		
Binder	18.0 min	18.0 min
Glass Beads	25.0 min	25.0 min
Titanium Dioxide	8.0 min	-----
Calcium Carbonate & Inert Fillers	49.0 max	-----

The binder shall be either alkyd or hydrocarbon. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least ½ of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by weight of the entire material formulation.

2. Physical requirements:

- a. **Water absorption:** Materials shall not have more than 0.5 percent retained water by weight when tested in accordance with the requirements of ASTM D570, Procedure A.
- b. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with the requirements of ASTM E28.
- c. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.
- d. **Impact resistance:** Impact resistance shall be at least 10 inch-pounds at 77 degrees F after material has been heated for 4 hours at 400 degrees F and cast into bars of 1 inch cross-sectional area, 3 inches long and placed with 1 inch extending above the vise in a cantilever beam, Izod-type tester, conforming to the requirements of ASTM D256, using the 25 inch-pound scale.
- e. **Drying time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.
- f. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
- g. **Glass beads:** Glass beads shall conform to the requirements of Section 234.

- h. **Flashpoint:** The material flashpoint shall be no less than 500 degrees F when tested in accordance with the requirements of ASTM D92.
- (d) **Polyester-Resin Pavement Marking Material (Type B, Class II):** Polyester-resin is a two-component pavement marking material suitable for use on hydraulic cement concrete surfaces.

1. **Composition (uncatalyzed material):**

	Min.	Max.
Pigment	36.0	40.0
Acrylic monomer	8.5	-----
Polyester resin	-----	55.5

2. **Physical requirements (uncatalyzed material):**

- a. **Viscosity:** Viscosity (25 degrees C), ASTM D562, shall be 80 to 90 Krieb units.
- b. **Weight per gallon:** Weight per gallon shall be at least 11.5 pounds.
- c. **Drying time:** The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a no-tracking condition in 15 minutes or less when applied at an application temperature of 77 degrees F to 100 degrees F, a substrate temperature of at least 60 degrees F, a wet thickness of 15 to 25 mils, and with 10 to 15 pounds of glass beads, conforming to the requirements of Section 234, applied per gallon. No-track time shall be determined by passing over the line with a passenger car or pickup truck at a speed of 25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered as showing “no-track” and conforming for time to “no-track”.
- d. **Catalyst:** The catalytic component of the system shall be a commercially available type recommended by the manufacturer of the polyester. The peroxide shall not be exposed to any form of heat, such as direct sunlight, radiators, open flame, or sparks. Heat may cause the organic peroxide to decompose violently or burn if ignited. The peroxide shall not come into contact with easily oxidized metals, such as copper, brass, or mild steel or galvanized steel as this can also initiate a violent reaction.
- e. **Weight loss:** Beaded catalyzed material shall not have a weight loss of more than 125 milligrams after 1,000 revolutions when abraded according to Federal Test Method Standard No. 141b, Method 6192, using CS-17 wheels with a 1,000-gram load on each wheel.

- f. **Shelf life:** The shelf life of uncatalyzed material shall be at least 6 months when stored in a cool area below 85 degrees F.
 - g. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
 - h. **Hiding:** The marking shall show a dry hiding quality that will give a contrast ratio of at least 0.96 with the Moresst Black and White Power Chart, Form 03B when drawn down at a fifteen (15) mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.
- (e) **Epoxy-Resin Pavement Marking Material (Type B, Class III):** Epoxy-resin is a two-component pavement marking material suitable for use on both asphalt and hydraulic cement concrete surfaces. Pigment, beads, and filler shall be well dispersed in the resin. Material shall be free from skins, dirt, and foreign objects and shall conform to the following:

1. **Composition**

Component	ASTM	White	Yellow
Epoxy resins	D1652	Max. 82%	Max. 77%
Titanium dioxide	D476 Type IV	Min. 18%	-----
Pigments	-----	-----	Min. 23%

2. **Physical requirements:**

- a. **Hardness:** Hardness, Shore D, ASTM D2240, shall be 75 to 100.
- b. **Tensile strength:** Tensile strength, ASTM D638, shall be at least 6,000 pounds per square inch after the material has cured for 72 hours at 73±4 degrees F.
- c. **Compression strength:** Compression strength, ASTM D695, shall be at least 12,000 pounds per square inch after the material has cured for 72 hours at 73±4 degrees F.
- d. **Adhesion to concrete:** Adhesion, ACI 503, shall be at 100 percent concrete failure after the material has cured for 72 hours at 73±4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch and shall be 90 degrees F when the material is applied.
- e. **Drying time:** Material shall dry to a “no-track” condition in 15 minutes or less at pavement temperatures from 50 degrees F to 120 degrees F and under all humidity conditions, providing the pavement is dry. No-track time shall be determined by passing over the line with a passenger car or pickup truck at a speed of

25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered as showing “no-track” and conforming for time to “no-track”.

- f. **Weight per epoxy equivalent:** Weight per epoxy equivalent of Part A of the epoxy pavement marking material shall be within ± 50 of the target value provided by the manufacturer when tested in accordance with the requirements of ASTM D1652
 - g. **Total amine value:** Total amine value of Part B of the epoxy pavement marking material shall be within ± 50 of the target value provided by the manufacturer when tested in accordance with the requirements of ASTM D2074.
 - h. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
 - i. **Abrasion resistance:** Wear index shall be no greater than 80 when abrasion resistance is tested in accordance with the requirements of ASTM D4060.
 - j. **Hiding:** The marking shall show a dry hiding quality that will give a contrast ratio of at least 0.96 with the Moresst Black and White Power Chart, Form 03B when drawn down at a fifteen (15) mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.
- (f) **Plastic-Backed Preformed Tape Pavement Marking Material (Type B, Class IV):** Plastic-backed preformed tape shall conform to the requirements of ASTM D4505 for a Type I or VI, Grade B, C, D or E material and any additions and/or exceptions indicated herein. Tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall be capable of being applied to previously applied marking material of the same composition under normal conditions of use. Tape shall be selected from the Department’s approved list. Tape products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways. Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO’s National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.
- 1. **Thickness (No Adhesive):** Thickness shall be at least 60 mils and no more than 90 mils.
 - 2. **Skid Resistance:** Skid resistance requirements for a Type I material shall be the same as required for a Type VI material.

3. **Initial Retroreflectivity:** Initial retroreflectivity requirements for a Type VI material shall be the same as required for a Type I material.
 4. **Maintained Retroreflectivity, Durability and Adhesion:** Maintained retroreflectivity, durability and adhesion shall conform to the following requirements after being installed on the test deck for 1 year:
 - a. **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least either 150 for 15 meter or 100 for 30 meter when measured in the skipline or centerline areas.
 - b. **Durability:** Tape shall have a durability rating of at least 4 when determined in the wheel path area.
 - c. **Adhesion:** No line shall have walked nor shall it be torn or missing.
- (g) **Construction Pavement Marking Materials:** Construction pavement markings shall consist of removable tape, non-retroreflective black removable tape and temporary pavement marking material. Construction pavement marking materials shall be selected from the Department's approved list. Products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways and the manufacturer has supplied information to the Department indicating conformance to the below warranty requirements for the tape products except Type E material will only be evaluated for asphalt concrete roadways. Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.
1. Removable Tape (Type D, Class I and II): Removable tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall conform to the following requirements:
 - a. **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.
 - b. **Warranty:** The manufacturer shall provide a full manufacturer's warranty on their product that shall cover the retroreflectivity, removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer's recommendations.

c. **Maintained Retroreflectivity, Removability and Adhesion:** Maintained retroreflectivity, removability and adhesion shall conform to the following requirements after being installed on the test deck for 90 days:

(1) **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15 meter or 30 meter when measured in the wheel path area.

Color	Coefficient of Retroreflected Luminance (R_L)			
	Type D, Class I (15 meter)	Type D, Class I (30 meter)	Type D, Class II (15 meter)	Type D, Class II (30 meter)
White	150	100	500	335
Yellow	100	65	335	225

(2) **Removability:** Removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3, and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.

(3) **Adhesion:** No line shall have walked nor shall it be torn or missing.

2. **Non-retroreflective Black Removable Tape (Type E):** Non-retroreflective black removable tape shall be suitable for use on asphalt concrete surfaces and shall conform to the following:

a. **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.

b. **Warranty:** The manufacturer shall provide a full manufacturer's warranty on their product that shall cover the removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer's recommendations.

c. **Removability and Adhesion:** Removability and adhesion shall conform to the following requirements after being installed on the test deck for 90 days:

(1) **Removability:** Removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3, and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.

(2) **Adhesion:** No line shall have walked nor shall it be torn or missing.

3. **Temporary Pavement Marking Material (Type F, Class I and II):** Temporary pavement marking material shall be suitable for use on asphalt and hydraulic cement concrete surfaces and shall conform to the following:

a. **Paint Products**

- (1) **Settling Properties:** Settling rating shall be at least 8 when tested in accordance with ASTM D869.
- (2) **Freeze-Thaw and Heat Stability:** Paint shall show no coagulation or change in viscosity greater than ± 5 KU when tested in accordance with the NTPEP test procedure.
- (3) **Water Resistance:** Paint shall show no blistering, peeling, wrinkling, softening or loss of adhesion when tested in accordance with the NTPEP test procedure.
- (4) **VOC:** The Volatile Organic Compound content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.

b. **Tape Products**

- (1) **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.
- (2) **Warranty:** The manufacturer shall provide a full manufacturer's warranty on their product that shall cover the retroreflectivity, removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer's recommendations.
- (3) **Adhesion:** No line shall have walked nor shall it be torn or missing after being installed on the test deck for 90 days.

c. **All Products (including paint and tape products)**

- (1) **Thickness:** Thickness shall be no greater than 40 mils.
- (2) **Maintained Retroreflectivity and Durability:** Maintained retroreflectivity and durability shall conform to the following requirements after being installed on the test deck for 90 days:

- a) **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15 meter or 30 meter when measured in the wheel path area.

Color	Coefficient of Retroreflected Luminance (R_L)			
	Type F	Type F	Type F	Type F
	Class I (15 meter)	Class I (30 meter)	Class II (15 meter)	Class II (30 meter)
White	150	100	290	190
Yellow	100	65	190	125

- b) **Durability:** Marking material shall have a durability rating of at least 4 when determined in the wheel path area.

SECTION 512—MAINTAINING TRAFFIC

512.01—DESCRIPTION.

This work shall consist of maintaining and protecting traffic through areas of construction, maintaining public and private entrances and mailbox turnouts, constructing and obliterating detours, and protecting the traveling public within the limits of the project and over detours that are not a part of the state highway system in accordance with the contract documents.

512.02—MATERIALS.

- (a) **Materials** salvaged from the roadway shall be used in the maintenance of traffic insofar as possible. Material shall conform to the requirements of the applicable specifications.
- (b) **Signalization, barricades, channelizing devices, safety devices, and pavement markings** shall conform to the requirements of Division VII Traffic Control Devices of these specifications and the *Virginia Work Area Protection Manual* except where otherwise indicated. Retroreflective surfaces shall conform to the requirements of Sections 235, 247 and 702 as applicable.
- (c) **Temporary pavement markers** shall conform to the requirements of Section 235.
- (d) **Construction pavement markings** shall conform to the requirements of Section 246.

- (e) **Construction signs** shall conform to the requirements of Section 247. Sign substrates for rigid construction signs mounted on posts shall conform to Section 701 or be a 0.079-inch thick aluminum/plastic laminate.

Sign substrates for signs mounted on drums, type III barricades and portable sign stands shall be of the materials listed below and shall be the same material that was used when the device was tested and found to be in compliance with the requirements of *National Cooperative Highway Research Program (NCHRP) Report 350, Test Level 3* or of other materials allowed in the FHWA acceptance letter.

SIGN SUBSTRATES FOR TYPE III BARRICADES AND PORTABLE SIGN STANDS

Rollup sign

0.4 inch thick corrugated polypropylene or polyethylene plastic

0.079 inch thick aluminum/plastic laminate

SIGN SUBSTRATES FOR DRUMS

0.4 inch thick corrugated polypropylene or polyethylene plastic

512.03—PROCEDURES.

Traffic shall be maintained and protected in accordance with the requirements of Sections 104.04 and 107.10. Work shall be scheduled and performed so as to provide minimum interference with and maximum protection to traffic. The Contractor's personnel, equipment, machinery, tools, and supplies shall be kept outside of clear zone and clear of active traffic lanes except as necessary for prosecuting active work. Stabilized construction entrances shall be used in construction areas where there is a potential for construction vehicles to track material from the construction site onto a paved surface. Material that is spilled or tracked onto the traveled pavement during prosecution of the work shall be promptly removed.

The Contractor shall maintain the traffic control devices which shall include but not be limited to: repositioning of displaced devices including traffic barrier service, replacement due to inadequate structural integrity including traffic barrier service, replacement due to loss of reflectivity, repair of defaced sheeting and legend, replacement of broken supports, repositioning of leaning signs so they are plum and the sign face is perpendicular to the pavement edge, cleaning of dirty devices and replacement of stolen or vandalized devices. Barricades, barriers, and other safety devices shall be inspected at least daily, and deficiencies shall be immediately corrected. Safety and protective devices furnished by the Contractor will remain the property of the Contractor and shall be removed from the project site upon completion of the work or as directed by the Engineer.

- (a) **Signs:** When Construction Signs is included in the contract as a pay item, the Contractor shall furnish and install temporary sign panels necessary for the project which shall include but not be limited to, maintenance of traffic, begin and end of construction, and off-project detour signing. When Construction Signs is not included in the contract as a pay item, the Department will furnish temporary sign panels necessary for maintenance of traffic, including those designating the beginning and end of construction, to the Contractor for installation. When the Department furnishes the temporary sign panels and off-project detour signing is required and the signing requirements are shown in the plans, the Contractor shall also install the detour signing. When the Department furnishes the construction signing and the detour signing requirements are not shown in the plans, the Department will furnish, install and maintain the detour signing except when the municipality is responsible for such work in accordance with Section 104.04(a).

Signs and their placement shall conform to the requirements of the *Virginia Work Area Protection Manual*, the *MUTCD*, plans and as directed by the Engineer. The Contractor shall submit to the Engineer a sketch of their proposed construction sign layout for approval prior to installation. The Contractor shall furnish supports (wood posts, barrier and wall attachments,) and hardware for use with the temporary sign panels. In lieu of using wood posts, the Contractor may request permission of the Engineer to use alternate products contained on the Special Products Evaluation List (SPEL). The request shall contain all information related to the manufacturer's installation requirements, including but not limited to, post spacing and square footage of sign panel the product can support based on AASHTO requirements for a 60 mph wind speed. The Contractor shall be responsible for covering, uncovering, or removing and reinstalling existing signs which conflict with the signs needed for maintenance of traffic. Covering of existing signs shall be accomplished in accordance with the requirements of Section 701.03(d). The Contractor shall also furnish and install flags for the temporary sign panels as directed by the Engineer except flags will not be required for use on portable sign supports. Signs shall be installed and attached to wooden supports in accordance with Standard WSP-1 of the Road and Bridge Standards. Size and number of wooden supports shall be in accordance with the Standard Drawings. When alternate products for supports are approved for use by the Engineer, the supports (including size and number) and signs shall be installed in accordance with the manufacturer's recommendation.

Non-retroreflective, flexible sign base materials and retroreflective, flexible sign base materials conforming to the requirements of Section 247 for a ASTM D4956 Type VI material will be permitted for use from 1 hour after sunrise to 1 hour before sunset until December 31, 2002. In addition, the retroreflective material may also be used for emergency (non-planned) nighttime operations not to exceed one night. Beginning January 1, 2003, all flexible sign base materials shall be retroreflective conforming to the requirements of Section 247 for material that is not ASTM D4956 Type VI material. During periods of low visibility, such as darkness, fog, rain, snow, or heavy overcast, temporary sign panels constructed of these materials shall not be used. Non-retroreflective, flexible sign base material shall be a single ply woven mesh weighing a minimum of 15 ounces per square yard. The yarn shall have a minimum diameter of .018 inches and shall be polyester core coated.

Retroreflective, flexible sign base materials conforming to the requirements of Section 247 for material that is not ASTM D4956 Type VI material may be used both day and night up to a maximum of 14 continuous days.

The Contractor may furnish portable sign stands for mounting temporary sign panels in accordance with the following:

1. Sign installations shall be used for no longer than 3 consecutive days (72 hours).
2. Portable sign stands shall be used with signs having a substrate material of the type required by Section 512.02(e) and only those that were tested and found to be in compliance with the requirements of *NCHRP* Report 350, Test Level 3 or of other materials allowed in the FHWA acceptance letter.

Portable sign stands shall be self-erecting and shall accommodate signs of the shape being utilized. Portable sign stands shall support a 16 square foot sign panel in 50 mph winds without tipping over, walking, or rotating more than ± 5 degrees about its vertical axis. Additional weight consisting of no more than one 25-pound sandbag placed on each leg or no more than two cone weights positioned on the center of the sign stand and around the mast may be used to accomplish this requirement. When used on uneven surfaces, the portable sign stand shall be capable of adjusting to those surfaces to allow the signs to be installed in their normal upright position ± 15 degrees. Portable sign stands shall include decals, stenciling or some other durable marking system that indicates the manufacturer and model number of the stands. Such marking shall be of sufficient size so it is legible to a person in a standing position.

Portable sign stands shall conform to the requirements of *NCHRP* Report 350, Test Level 3 and shall be selected from those shown on the Department's Approved List or the Contractor shall submit a certification letter stating the brands and models of portable sign stands to be used along with a copy of the FHWA acceptance letter indicating compliance with *NCHRP* Report 350, Test Level 3 shall be submitted prior to their use.

Tripod sign stands will not be allowed for use on any roadway.

The Contractor shall erect, maintain, move and be responsible for the security of sign panels and shall ensure an unrestricted view of sign messages for the safety of traffic. The Contractor shall maintain and store signs furnished by the Department in a manner approved by the Engineer until they are returned to the Department.

When construction signs are covered to prevent the display of the message, the entire sign shall be covered with silt fence or other materials approved by the Department such that no portion of the message side of the sign shall be visible. Plywood shall be used on ground-mounted construction signs only. Attachment methods used to attach the covering

material to .the signs shall be of a durable construction that will prevent the unintentional detachment of the material from the sign. At no times shall a construction sign and/or post be rotated to prevent the display of the message. In addition, the posts where the signs are being covered shall have two ED-3, Type II delineators mounting vertically on the post below the signs at a height of 4 feet to the top of the topmost delineator. The bottom delineator shall be mounted 6 inches below the top delineator.

- (b) **Flagger Service and Pilot Vehicles:** The Contractor shall provide flagger in accordance with the requirements of Section 104.04(c).

When one-way traffic is approved, the Contractor shall provide flagger service and, where necessary, pilot vehicles to maintain traffic. Each vehicle shall be equipped with at least one roof-mounted rotating amber flashing light and shall display required signs while in service.

- (c) **Electronic Arrows:** Electronic arrows shall be electronic flashing or sequential amber arrows having dimmer controls and shall be mounted on suitable trucks or trailers. The Contractor shall maintain and move electronic arrows as needed for traffic control.

Trailers supporting arrow boards and the boards themselves shall be either Virginia highway orange (DuPont Color #LF74279 AT or color equivalent) or federal yellow in color. The trailer's back frame shall have 2-inch height retroreflective sheeting conforming to the requirements of Section 247.02(c) installed on the area facing traffic. The sheeting shall have alternating 11-inch width vertical red stripes and 7-inch width vertical white stripes.

- (d) **Warning Lights:**

1. **Type A flashing lights** shall be used for advance warning signs and hazardous locations and shall be in operation during hours of darkness and low visibility. A Type A flashing light shall be installed on concrete traffic barrier service at the break point between the transition and tangent sections.
2. **Type B flashing lights** shall be used when specified on the plans for advanced warning signs and extremely hazardous locations and shall be in operation at all times.
3. **Type C steady burn lights** shall be used when specified on the plans for channeling traffic and may be placed on Group 2 channelizing devices. When used on Group 2 channelizing devices, the channelizing devices shall have been tested with the light and a FHWA acceptance letter issued indicating compliance with *NCHRP* Report 350, Test Level 3 as required in Section 512.03(e). Lights shall be placed at intervals of 80 feet along tangent sections and 40 feet along bridges, transitions, and curves greater than 6 degrees. Lights shall be in operation from 30 minutes before sunset until 30 minutes after sunrise, on heavy overcast days, in fog, and during periods of darkness or low visibility as directed by the Engineer.

- (e) **Channelizing devices** purchased after October 1, 1998 with the exception of drums/cones with an auxiliary device (sign, light, etc.) attached and portable vertical panel assemblies shall conform to the requirements of *NCHRP* Report 350, Test Level 3. Drums/cones with an auxiliary device attached and portable vertical panel assemblies purchased after October 1, 2000 shall conform to the requirements of *NCHRP* Report 350, Test Level 3. However, beginning January 1, 2003, all channelizing devices shall conform regardless of the purchase date.

Channelizing devices shall be selected from those shown on the Department's Approved List beginning with the above applicable purchasing dates. The Contractor shall provide a certification letter stating the brands and models of channelizing devices contained on the listing that will be used. In lieu of using channelizing devices on that listing, the Contractor may utilize other brands and/or models conforming to specification requirements provided he submits catalog cuts/brochures of each brand and model prior to their use and the following requirements:

1. Channelizing devices except drums/cones with an auxiliary device attached and portable vertical panel assemblies -- A copy of a self-certification letter from the manufacturer that the specific channelizing device is crashworthy – that it will meet the evaluation criteria of the *NCHRP* Report 350. This self-certification may be a one-page affidavit signed by the manufacturer.
2. Drums/cones with an auxiliary device attached, and portable vertical panel assemblies with or without an auxiliary device attached – A copy of the FHWA acceptance letter indicating compliance with *NCHRP* Report 350, Test Level 3.

Also, the Contractor shall provide, when applicable, a certification letter indicating that those channelizing devices being used that are not contained on the Department's Approved List and for which no catalog cuts/brochures and self-certification are being supplied were purchased prior to October 2, 1998 or October 2, 2000, as applicable.

Spacing of channelizing devices shall be in accordance with the *Virginia Work Area Protection Manual*.

- a. **Group 1 devices** shall consist of tubular delineators or cones approximately 36 inches in height for interstate and other limited access roadways and approximately 28 inches in height for other roadways. They shall be used as temporary channelizing devices. When used during hours of darkness, they shall be provided with reflectorized collars or sleeves.
- b. **Group 2 devices** shall be drums or vertical panels. Drums shall be round, or round with no more than one flatside, made from plastic, have a minimum height of 36, have a cross-sectional width no less than 18 inches in any direction and conform to the *Virginia Work Area Protection Manual*. Drum shall be designed to allow for separation of ballast and drum upon vehicular impact, but not from wind and vacuum

created by passing vehicles. Drums of two piece design (drum and associated base) shall utilize sufficient amounts of enclosed sand at the base in accordance with the manufacturer's recommendations to provide stable drum support. The base shall be not greater than 5 inches in height. Two-piece drums may also utilize a flared drum foundation and collar of not more than 5 inches in height and of suitable shape and weight to provide stable support. One-piece drums may be used provided they meet the above requirements.

Vertical panels shall be mounted on posts conforming to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Vertical panels will be allowed only for use in locations indicated in the contract documents. Non-portable vertical panels shall be mounted on posts conforming to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Open top drums will not be allowed. Markings on drums shall be horizontally circumferential, alternating from the top of the drum with orange and white, 6-inches wide, retroreflective stripes. Each drum shall have a minimum of two orange and two white stripes and the top stripe shall be orange. Any non-retroreflective areas on the drum except the base shall be orange in color and spaces between retroreflective stripes shall not exceed 2 inches in width.

The Contractor shall also furnish and install signs (Stop, Chevron, Keep Right, etc.) for the drums as directed by the Engineer. Sign panels used on drums tested for conformance to NCHRP requirements shall be of the same material as that used for the test except that materials as allowed by the FHWA acceptance letter may be used when approved by the Department.

- (f) **Traffic Barrier Service:** Barrier service shall be of sufficient length to protect traffic and personnel in construction areas.

The Contractor shall continuously prosecute the work until completion once a barrier is in place. If the Contractor does not, the Department may cause him to discontinue operations in other areas on the project and concentrate efforts behind the traffic barrier service. When construction work is completed to the extent that traffic barrier service is no longer required as determined by the Engineer, devices shall be removed.

Neither workers nor equipment shall traverse areas confined by traffic barrier service and travel lanes except as approved by the Engineer and then only with adequate flagger service to safeguard workers and traffic in advance of and at the point the traffic barrier service is opened. Barrier openings for construction access may be provided only along tangent sections or along the inside of curved sections and shall be limited to the minimum length required for equipment access. The normal pavement alignment at the barrier opening shall be maintained with removable pavement marking. At ingress openings, the exposed end

of the barrier service shall be provided with a temporary impact attenuator as approved by the Engineer. At egress openings, the exposed end shall be transitioned as dependent on the posted speed for traffic. The transition flare rate shall be in accordance with the requirements of the *Virginia Work Area Protection Manual*. For speeds below 30 mph, the transition flare rate shall be the same as that indicated for 30 mph. An impact attenuator will not be required at the exposed end of egress openings in barrier service provided the deflection angle between the pavement edge and ends of the barrier service openings is 20 degrees or more.

Delineators shall be installed on traffic barrier service in accordance with the requirements of Section 702. Barrier vertical panels shall be installed on top of the concrete barrier service. Reflectorized sheeting shall be in accordance with the requirements of Section 247. Design and installation of barrier vertical panels shall be in accordance with the requirements of the *Virginia Work Area Protection Manual*.

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain warning lights, delineators, and other devices in a clean and visible condition at all times.

1. **Guardrail barrier service and terminal treatments** shall be installed in accordance with the requirements of Section 505 except that the offset distance shall be as specified by the Engineer. The Contractor may reuse guardrail used for traffic barrier service guardrail for permanent installation provided the guardrail material conforms to the requirements of Section 505 and the standard drawings and is acceptable to the Engineer. Marred galvanized surfaces shall be repaired in accordance with the requirements of Section 233.
2. **Concrete barrier service** shall be installed in accordance with the plans and standard drawings or as directed by the Engineer. When barrier terminates at a guardrail, fixed object attachments connecting the barrier to the guardrail shall be installed in accordance with the applicable standard for fixed object attachment. Installation shall include additional guardrail posts and attachments as required. Concrete barrier connections shall be snug to prevent motion between sections.

Precast concrete parapet for precast concrete parapet traffic barrier service shall be anchored as shown on the plans. Anchor holes in bridge decks shall be drilled with a rotary impact drill or other approved equipment that will prevent damage to the deck. Anchor holes shall be located so as to avoid cutting reinforcing steel. Upon removal of the parapet, anchor holes shall be cleaned and filled with Type EP-4 or EP-5 epoxy mortar conforming to the requirements of Section 243.

Parapet used for concrete parapet traffic barrier service will not be permitted for permanent installations on bridge structures.

The Contractor shall visually inspect all traffic barrier service shipped to a project prior to placing it in use. Concrete barrier sections shall be structurally sound with no concrete missing along the top surface and no through cracks. Any traffic barrier service found by the Contractor to be unacceptable due to inadequate structural integrity or functionality shall be removed from the project site. The Contractor shall furnish a self-certification to the Engineer for the traffic barrier service stating that traffic barrier service has been inspected and found to be in conformance with *NCHRP 350* requirements and is acceptable for use.

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain warning lights, barrier vertical panels, delineators, and other devices in a clean and visible condition at all times. Concrete barrier service shall be cleaned or coated sufficiently to afford good visibility and uniformity of appearance.

- (g) **Impact Attenuator Service:** Impact attenuator service shall be installed at locations shown on the plans or designated by the Engineer. A modified Type III object marker shall be installed on impact attenuators.

- (h) **Temporary Signalization:** When specified on the plans, the Contractor shall install and maintain temporary signalization equipment. The Contractor shall submit to the Engineer a plan for installing and maintaining signals that shall depict also the Contractor's intent for maintaining traffic flows, including phase sequencing and timings. The Contractor shall receive approval of the plan from the Engineer prior to beginning work that would necessitate installing the proposed temporary signalization. The Contractor's design shall conform to the requirements of the applicable sections of these specifications and standard drawings. Portable traffic signal equipment (PTSE) will be allowed for temporary one-way bridge signals and then only when specified in the pay item. New, salvaged or refurbished materials may be used, however new materials shall be used for temporary signalization equipment when it is specified in the contract documents that such equipment is to become the property of the Department or municipality after project completion. Materials, except for PTSE, shall conform to the requirements of the applicable specifications and standard drawings except that controllers which are not designated to become the property of the Department or municipality after project completion will need to conform only to the requirements of NEMA TS-1 and controller cabinet accessory and auxiliary equipment need include only an NEMA conflict monitor and equipment necessary to produce and monitor the phasing required unless otherwise indicated.

PTSE shall conform to the following requirements:

1. Shall conform to the operational requirements of the MUTCD.

2. Shall place all units in flashing red when a conflict or a communication loss is detected.

3. Shall be a trailer mounted type conforming to the requirements of the MUTCD with at least one of the two traffic signal heads capable of being positioned over the roadway.
4. Shall operate from its own self-contained power supply with the capability of connecting to an external 110-volt electrical power supply.
5. Shall utilize 12-inch traffic signal head sections mounted in the vertical display arrangement and shall include backplates.
6. Traffic signal heads and backplates shall conform to Sections 238 and 703 except that LED traffic signal head sections may be used for the red and green ball indications. LED traffic signal head sections shall conform to the latest ITE Interim LED Purchase Specification – Vehicle Traffic Control Signal Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules. The Contractor shall provide the manufacturer's certificate of ITE compliance for the LED modules. No amber ball or any color arrow indication LED traffic signal head sections will be allowed for use.
7. Shall incorporate some form of vehicular detection that will detect all vehicles unless otherwise indicated in the plans or the contract.
8. Shall have adequate safeguards to prevent unauthorized entry to the control equipment.
9. Shall be interconnected via hardwire unless otherwise indicated in the plans or the contract.
10. Shall be a stable design that shall not overturn in an 80-mph wind gust.
11. Trailer and framework shall be painted Federal Yellow or Virginia Highway Orange (DuPont Color #LF74279 AT or color equivalent).
12. Shall be sufficiently chained to an anchoring device or one wheel shall be removed to discourage unauthorized removal during times when the contractor's personnel are not on site.
13. Shall be installed behind guardrail or barrier when installed in the clear zone.
14. Shall be installed on the right side of the road unless otherwise approved by the Engineer.
15. The trailer's back frame shall have 2-inch height retroreflective sheeting conforming to the requirements of Section 247.02(c) installed on the area facing traffic. The sheeting shall have alternating 11-inch width vertical red stripes and 7-inch width vertical white stripes.

Temporary signalization that is not specified on the plans but is installed by the Contractor for his convenience shall be installed at his expense and shall be approved through the process described herein. Maintenance and operation of these temporary signals shall be the responsibility of the Contractor.

The Contractor shall make arrangements with the local utility company for temporary electrical service with the exception of temporary service for existing signals that are relocated or adjusted. The Contractor shall also be responsible for the costs of connections and disconnections and energy costs. Arrangements and payment for temporary service for existing signals that are relocated or adjusted will be made by the Department. If electrical service is not available, the Contractor shall provide a generator capable of continuously operating for at least 24 hours. The Contractor shall demonstrate the signal's operational procedures and reliability to the Engineer for approval prior to beginning work necessitating use of the equipment.

Signal equipment designated in the Contract or on the plans to be turned over to the Department at project completion shall be delivered by the Contractor to a designated site.

- (i) **Construction Pavement Markings:** Construction pavement markings shall be installed at locations shown on the plans and in the *Virginia Work Area Protection Manual*, and at other locations as directed by the Engineer. Construction pavement markings shall be selected from the Department's approved list of Construction Pavement Marking Materials. Construction pavement markings are classified as Types D, Classes I and II (removable tape), E (non-reflective black removable tape) and F, Classes I and II (temporary markings). Construction pavement markings shall be used as follows:
1. **Type D construction pavement markings** shall be used on final roadway surfaces or in areas where traffic patterns are subject to change before pavement is resurfaced unless the surface temperature of the pavement is below the pavement marking manufacturer's recommended minimum application temperature. When the surface temperature of the pavement is below the manufacturer's minimum application temperature, a Type F construction pavement marking on the approved list under the same class as the specified Type D construction pavement marking may be used except on final surfaces. The Contractor shall select a Type F product known to perform the best under those temperature conditions. When a Type F construction pavement marking is utilized in lieu of a Type D due to the surface temperature being below the manufacturer's minimum application temperature, the Contractor will be paid the price bid for Type D, which will include the Type F markings and any necessary eradication of existing pavement markings.
 2. Type E construction pavement markings shall be used to cover existing markings in accordance with Section 512.03(j).
 3. Type F construction pavement markings shall be used where the roadway is to be resurfaced prior to changes in the traffic pattern or where pavement is to be demolished and traffic patterns will not change before demolition.

Construction pavement markings shall be installed in accordance with the manufacturer's recommendations. Application thickness and bead application shall be in accordance with the manufacturer's recommendations except as follows. In the event the manufacturer's recommendation for material thickness and quantity of beads is less than utilized when the material was tested by the National Transportation Product Evaluation Program (NTPEP), the minimum values used during product installation shall conform to the NTPEP test values which are indicated on the approved list for the specific marking. The Contractor shall furnish a copy of the manufacturer's installation recommendations including the thickness, bead embedment and dispersment to the Engineer.

The Contractor shall maintain the construction pavement markings and shall correct any deficient markings by reapplying markings. Deficient construction pavement markings are considered to be any markings that do not provide adequate guidance to motorists due to inadequate retroreflectivity or color qualities, or due to problems with adherence to the pavement. The Engineer will make a visual nighttime inspection of all construction pavement markings to identify areas of markings that have inadequate retroreflectivity qualities.

Those markings that have inadequate retroreflectivity qualities as determined by the Engineer shall be replaced by the Contractor with the following exceptions:

- a. Reapplication of skip line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least two consecutive skip lines.
- b. Reapplication of center, lane (except skip lines) or edge line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section of 70 feet.
- c. Reapplication of transverse markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section exceeding 3 feet.

In lieu of replacement of construction pavement markings based on visual observations by the Engineer, the Contractor may have retroreflectivity readings made. These measurements shall be taken within 48 hours after the Contractor has been notified of the deficient markings except additional time will be granted due to inclement weather that prevents the adequate measurement of the markings. The Contractor shall brush any form of debris from the line before performing the measurements. Measurements shall be taken in the presence of the Engineer using Contractor furnished equipment conforming to the requirements of ASTM E1710. The Contractor shall operate the equipment in accordance with the manufacturer's instructions and a copy of such instructions shall be provided to the Engineer. The photometric quantity to be measured is coefficient of retroreflected luminance (R_r) which shall be expressed as millicandelas per square foot per foot-candle.

Measurements shall be accomplished at three random locations within each area of markings that have inadequate retroreflectivity qualities. When the length of the visually inadequate area is greater than one mile, measurements shall be accomplished at three locations per mile segment or portion thereof. Measurements for all lines shall be accomplished in the middle of the line horizontally. Measurements for skip lines shall be accomplished in the middle of its length. Measurements for transverse lines shall be taken outside of the wheel path locations. The Engineer will designate the locations along the line segments that the measurements shall be taken. The Contractor shall make a log of the measurements along with their locations and provide a copy to the Engineer. When the average of the three readings for an area is below 100 millicandelas per square foot per footcandle, the Contractor shall reapply the markings as indicated above.

Construction pavement markings that have become unadhered to the pavement shall be reapplied by the Contractor with the following exceptions:

1. Reapplication of skip line construction pavement markings is not required unless the unadherence is for at least two consecutive skip lines.
2. Reapplication of center, lane (except skip lines) or edge line construction pavement markings is not required unless the unadherence is for at least a continuous section of 70 feet.
3. Reapplication of transverse markings is not required unless unadherence is for at least a continuous section exceeding 3 feet.

However, all construction pavement markings that have become unadhered to the roadway that may cause guidance problems for the motorists shall be removed by the Contractor.

Removable construction pavement markings shall also be replaced on tined concrete and high hit asphalt locations on time frames as recommended by the manufacturer of the marking to prevent the need for eradication. The Contractor shall furnish a copy of the manufacturer's recommendations to the Engineer.

Those construction pavement markings found in need of reapplication in accordance with the above requirements shall be reapplied by the Contractor at no additional cost to the Department with the following exceptions:

- a) Markings that have been under traffic for more than 90 days will be paid for at the contract unit price when needing reapplication unless the manufacturer's warranty coverage is still in effect.
- b) Markings damaged by the Department's snow removal or other maintenance and construction operations will be paid for at the contract unit price.

Construction pavement markings shall be replaced in accordance with the time requirements of Section 704.

Eradication for reapplication of Type F construction pavement markings is not required if allowed by the marking manufacturer provided the existing marking is well adhered and the total thickness of both the existing and reapplied marking combined will not exceed 40 mils. If not well adhered, 90 percent of the existing markings shall be removed prior to reinstallation of the markings. Temporary pavement markers shall be installed with construction pavement markings in accordance with (k) herein.

- (j) **Eradicating Pavement Markings:** Markings that may conflict with desired traffic movement, as determined by the Engineer, shall be eradicated as soon as is practicable: either immediately prior to the shifting of traffic or immediately thereafter and prior to the conclusion of the workday during which the shift is made.

Eradication shall be performed by grinding, blasting, or a combination thereof. Grinding shall be limited to removal of material above the pavement surface except when removing thermoplastic and preformed tape markings, which may be removed by grinding alone. Blasting shall be used on both asphalt concrete and hydraulic cement concrete pavements to remove all other types of markings. Other methods may be submitted for approval by the Engineer. The Contractor shall ensure that the least amount of damage as possible occurs to the roadway surface when accomplishing the eradication.

When eradicating pavement markings, the Contractor shall ensure workers are protected in conformance to the requirements of *Occupational Safety and Health Administration's (OSHA)* standards as detailed in 29 CFR 1910 or 1926, whichever is the most stringent at the time. The Contractor shall collect the eradication residue during or immediately after the eradication operation, except dust shall be collected during the entire operation. Eradication residue from the removal of any pavement markings is considered to be a non-hazardous waste material and shall be disposed of in a properly permitted waste disposal facility in accordance with state and federal laws and regulations. Testing of the eradication residue for the eight RCRA metals will not be required.

When markings are removed for lane shifts/transitions, 100 percent of the marking shall be removed.

Non-reflective removable black construction pavement marking may be used to cover existing markings in lieu of eradication methods on asphalt concrete surfaces when its use will not be required for more than 120 days and when specified as a pay item. The Contractor shall use this material to cover markings as indicated in the plans or as directed by the Engineer. Non-reflective removable black construction pavement marking shall be applied in accordance with the manufacturer's recommendations.

- (k) **Temporary pavement markers** shall be installed with construction pavement markings, except non-reflective removable markings, in transition (lane drop) or lane shift areas of work zones which will encroach upon the traveled roadway for a period of more than three days and in other areas as required by the Engineer.

Temporary pavement markers shall be installed on twenty-foot centers in lane shift and transition areas. When temporary pavement markers are required in other areas, they shall be installed on forty-foot centers unless otherwise required by the Engineer. Temporary pavement markers shall be located between and in alignment with broken lines and beside solid line pavement markings. Where double line pavement markings separating traffic are installed, two-way markers shall be installed beside each line. The Contractor may install two one-way markers in lieu of each two-way marker at no additional cost to the Department.

Temporary pavement markers shall be installed with a hot applied bitumen adhesive except epoxy may be used on hydraulic cement concrete roadways and non-final surfaces of asphalt concrete roadways. Damage created in the pavement by removal of markers shall be repaired in kind by the Contractor at no additional cost to the Department.

Temporary pavement markers found in need of replacement shall be replaced by the Contractor at no additional cost to the Department except those markers damaged by the Department's snow removal operations or other maintenance and construction operations will be paid for at the contract unit price.

- (l) **Detours:** Where temporary structures are necessary, they shall be designed and provided by the Contractor and of sufficient strength, width, and design to accommodate the volume and character of traffic using the highway. Temporary structures crossing waterways shall provide necessary hydraulic openings to accommodate the flow of the waterway. Temporary structure designs shall be submitted to the Engineer for review.

When a detour is no longer required, as determined by the Engineer, it shall be promptly removed, and the materials shall be disposed of as approved or directed by the Engineer. The Contractor shall design and provide temporary drainage facilities of adequate size to carry the normal flow of the existing drainage or waterway.

- (m) **Aggregate Material:** Aggregate material shall be placed at crossovers, private entrances, mailbox turnouts, and where specified by the Engineer.
- (n) **Construction Pavement Message Markings:** Markings shall be installed at locations designated on the plans and as determined by the Engineer and shall consist of messages in accordance with the requirements of Section 704. Construction pavement message marking material including maintenance of the markings shall be in accordance with the requirements for construction pavement markings.

Retroreflective measurements shall be taken out of the wheel path locations and each separate entity of a pavement message marking shall be replaced when the average of the three readings for that entity is below 100 millicandelas per square foot per footcandle.

- (o) **Type III Barricades** shall conform to the requirements of the plans except those purchased or built by the Contractor after October 1, 2000 shall conform to the requirements of *NCHRP* Report 350, Test Level 3 and be at least 4 feet in width. However, beginning January 1, 2003, type III barricades shall conform regardless of the purchase date. Type III barricades beginning October 2, 2000 shall be selected from those shown on the Department's Approved List. The Contractor shall provide a certification letter stating the brands and models of type III barricades contained on the listing that will be used. In lieu of using type III barricades on that listing, the Contractor may utilize other brands and/or models provided he submits prior to their use a copy of the FHWA acceptance letter indicating compliance with *NCHRP* Report 350, Test Level 3. Also, until January 1, 2003, the Contractor shall provide, when applicable, a certification letter indicating that those type III barricades being used that are not contained on the Department's Approved List and for which no FHWA acceptance letters are being supplied were purchased or built by the Contractor prior to October 2, 2000.
- (p) **Truck mounted attenuators** shall conform to the requirements of the *National Cooperative Highway Research Program (NCHRP)* Report 230, test numbers 50, 51, 52 and 54 or Report 350, Level 2 or 3 with the following exceptions:

Truck mounted attenuators purchased after October 1, 1998 shall conform to the requirements of Report 350, Level 2 or 3.

Truck mounted attenuators shall conform to the requirements of Report 350, Level 3 beginning January 1, 2003 regardless of the truck mounted attenuator purchase date.

All tests conducted in accordance with Report 230 shall have been conducted at 45 or 60 mph.

Prior to their use, the Contractor shall submit catalog cuts/brochures of the truck mounted attenuator and the following:

For truck mounted attenuators conforming to NCHRP 350, a copy of the FHWA's acceptance letter documenting acceptance of the specific truck mounted attenuator as conforming to such.

For truck mounted attenuators conforming to NCHRP 230, a copy of a certification from the truck mounted attenuator manufacturer indicating the specific truck mounted attenuator has been tested and conforms to the above test requirements.

The certification shall include a complete description of the above tests. In addition, the Contractor shall supply a dated sales receipt as documentation that the truck mounted attenuator was purchased prior to October 2, 1998. In the event that a dated sales receipt is not available and the truck-mounted attenuator was purchased prior to October 2, 1998, the Contractor shall provide a certification letter that the specific truck mounted attenuator was purchased prior to October 2, 1998.

The truck-mounted attenuator shall be no less than 72 inches wide and no more than 96 inches wide. Color of the truck-mounted attenuators shall be yellow or orange.

The rear panel shall have alternate 6-inch width orange and black chevron (inverted v) stripes. Stripes shall be sloped at a 45 degrees angle downward in both directions from the upper center of the rear panel. Stripes shall be fabricated from fluorescent orange prismatic lens reflective sheeting conforming to Section 247.02(e).

Weight of the support truck shall be as recommended by the truck mounted attenuator manufacturer. The Contractor shall provide a copy of the manufacturer's recommendation to the Engineer and a copy of a weigh ticket for the truck. The weigh ticket shall contain adequate information to properly associate the ticket with the applicable truck. Additional weight may be added to the support vehicle to achieve the range recommended by the truck mounted attenuator manufacturer provided the total weight is within the GVWR of the support vehicle and is installed such that no movement will occur during impacts.

The support vehicle shall have at least one rotating amber light or high intensity amber strobe light functioning while in operation in accordance with the *Virginia Work Area Protection Manual*. When allowed by the *Virginia Work Area Protection Manual*, an electronic arrow operated in the caution mode may be used in lieu of the rotating or high intensity amber strobe light.

The support vehicle with the truck mounted attenuator in use shall have the transmission in second gear (park for automatics) with the parking brake applied and the front wheels aligned straight ahead when operating in the stationary mode.

Limitations: Support vehicles shall not be used for other purposes while the truck mounted attenuator is being used. There shall be no additional devices in the bed of the support vehicle except the additional weight as allowed by Section II and traffic control devices such as truck-mounted electronic arrows. There shall be no additional devices, including but not limited to, signs, lights, and flag holders attached to the truck mounted attenuator except those that were tested on the truck mounted attenuator and provided by the truck mounted attenuator manufacturer.

In the event the truck mounted attenuator is impacted, resulting in damage which would cause the unit to be ineffective, all work requiring the use of the truck mounted attenuator shall cease until such time that the Contractor can provide an acceptable unit, by means of repair or replacement.

Work performed in conjunction with Sections 512.03(i), (j), (k) and (n) shall be in accordance with Section 704 except as noted herein.

Replacement and correction of ineffective work zone traffic control devices shall be accomplished in accordance with the *American Traffic Safety Service Association's (ATSSA) Quality Standards For Work Zone Traffic Control Devices* publication with the following additions and exceptions:

1. Requirements herein for replacement and correction of construction pavement markings shall be used in lieu of the requirements contained in the section entitled Evaluation Guide Pavement Tape & Raised Pavement Markers.
2. The categories for Arrow Panel (Flashing Arrow and Double Arrow Mode) are replaced by the following:

Acceptable:

No lamps out in stem and arrow head(s), and dimming properly.

Marginal:

No more than 1 lamp out in the stem and no lamps out in the head(s), and dimming properly.

Unacceptable:

Any lamp out in the head(s) or more than 1 lamp out in the stem, or arrow panel not dimming properly.

3. Arrow Panel (Caution Mode - Bar or Corners) is replaced by the following

EVALUATION GUIDE - ARROW PANEL (CAUTION MODE - CORNERS)

Acceptable:

No lamps out and dimming properly.

Unacceptable:

Any lamp out or arrow panel not dimming properly.

Note: Any operating lamp that is out of alignment will be considered not functioning.

4. The unacceptable category for arrow panels shall require immediate corrective action if the device is found in operation on the jobsite.

512.04—MEASUREMENT AND PAYMENT.

Flagger service will be measured in hours as authorized or approved by the Engineer except when used for the Contractor's convenience, such as for ingress and egress for moving construction equipment or materials. In such cases, payment will not be made for flagger service. Flagger service will be paid for at the contract unit price per hour. This price shall include paddles and safety equipment.

Pilot vehicles will be measured in hours of actual use, as required by the Engineer, and will be paid for at the contract unit price per hour. This price shall include vehicles, necessary warning devices, drivers, fuel, and maintenance.

Electronic arrows will be measured in hours of actual use, as required by the Engineer, except when used as an option to the use of a rotating amber light or alternating high intensity amber strobe light. In such cases, payment will not be made for electronic arrows. Electronic arrows will be paid for at the contract unit price per hour. This price shall include arrow panels, fuel, maintenance, and a truck or trailer having flashing amber warning lights.

Warning lights for use on sign panels will be measured in days of actual use for the type specified, and will be paid for at the contract unit price per day. This price shall include maintaining, relocating, and removing. Warning lights installed on traffic barrier service will not be measured for separate payment, but the cost thereof shall be included in the linear foot price bid for traffic barrier service.

Group 1 channelizing devices will not be measured for separate payment. The cost thereof shall be included in the price for other appropriate pay items.

Group 2 channelizing devices, as required by the Engineer, will be measured in days and will be paid for at the contract unit price per day. This price shall include maintaining devices, removing devices when no longer required and signs. When group 2 channelizing devices are moved to a new location or are removed and re-installed at the same location, they will be measured for separate payment. However, when the group 2 channelizing devices are moved from one lane to another by simply moving the devices across the lane edge line without removal from the roadway, no additional payment will be made.

Traffic barrier service will be measured and paid for at the contract unit price per foot per location. This price shall include warning lights, delineators, barrier vertical panels, fixed object attachments, patching restraint holes, maintaining, and removing when no longer required. When fixed object attachments are used on traffic barrier service in locations where existing guardrail is in place, this price shall include restoring existing guardrail to its original condition. When traffic barrier service is moved to a new location as directed or approved by the Engineer, the relocation will be measured for separate payment. Payment for traffic barrier service will not be made until the work behind the barrier is actively pursued.

Traffic barrier service guardrail terminal will be measured and paid for in units of each or linear feet, as applicable, which price shall include furnishing, installing and removing when no longer needed. When traffic barrier service guardrail terminal is moved to a new location, as directed or approved by the Engineer, the relocation will be measured for separate payment.

Impact attenuator service will be measured in units of each and will be paid for at the contract price per each. Impact attenuators used with barrier openings for equipment access will not be measured for separate payment.

Temporary signalization will be paid for on a lump sum basis. This price shall include, but not be limited to, poles; span wire; conduit; conductor cable; traffic signal heads; hanger assemblies; necessary control items; maintaining, adjusting, and aligning equipment; electrical service; utility company costs; removing; and delivering equipment.

Construction pavement markings will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include marking materials, preparing the surface, adhesive, maintaining, removing removable markings when no longer required, inspections, and testing

Construction pavement message markings will be measured in units of each and will be paid for at the contract unit price per each. This price shall include marking materials, preparing the surface, adhesive, maintaining, and removing removable markings when no longer required.

Temporary pavement markers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing pavement markers, surface preparation, adhesive, and maintaining and replacement of lost or damaged markers and removing the pavement markers and adhesive when no longer required.

Eradication of existing pavement markings will be measured in linear feet of a 6-inch width or portion thereof. Widths that exceed a 6-inch increment by more than ½ inch will be measured as the next 6-inch increment. Eradication of pavement markings will be paid for at the contract unit price per linear foot. This price shall include removing pavement line markings and messages and disposal of residue.

Temporary detours will be measured in linear feet along the centerline of the detour or by individual components with the quantities shown on the plans as maintenance of traffic items, in which the components will be measured in accordance with the applicable specifications. This price shall include removing and restoring. When a pay item, temporary detour will be paid for at the contract unit price per linear foot. This price shall include excavating, aggregate materials, drainage items, grading, asphalt, maintaining, removing detour, disposing of surplus and unsuitable material, and restoring property.

Aggregate material will be measured in tons and will be paid for at the contract unit price per ton for the type specified. This price shall include preparing the grade and furnishing, placing, maintaining, and removing material as required.

Type III barricades will be measured in units of each and will be paid for at the contract bid price per each for the width specified. Multiple 4 foot width type III barricades may be used together to obtain the width being specified in the pay item. This price shall include the barricades, retroreflective sheeting, maintaining, relocating to new locations and removing when no longer required.

Construction signs when furnished by the Contractor will be measured in units of square feet and will be paid for at the contract bid price per square foot. This price shall include furnishing, installing, maintaining, covering and uncovering, relocating and removing temporary sign panels, sign supports, hardware, delineators and flags. Payment based on square footage shall be compensation for the sign(s) for the duration of the project; multiple payments for the same sign used more than once will not be allowed. Construction signs when furnished by the Department will not be measured for separate payment. The cost thereof shall be included in the price bid for other appropriate pay items.

Truck mounted attenuator will be measured in hours of actual use and will be paid for at the contract unit price per hour. This price shall include the truck mounted attenuator, support vehicle, lights, electronic arrows, if allowed but not required, and maintenance. When electronic arrows are used at the option of the Contractor in lieu of the rotating or high intensity amber strobe light, the cost of the electronic arrow shall be included in the price bid for truck mounted attenuators. When electronic arrows are required and not only allowed on the truck mounted attenuator support vehicles, they will be paid for separately.

Payment will be made under:

Pay Item	Pay Unit
Flagger service	Hour
Pilot vehicle	Hour
Electronic arrow	Hour
Warning light (type)	Day
Group 2 channelizing device	Day
Traffic barrier service (Type and/or standard)	Linear foot
Traffic barrier service Guardrail terminal (standard)	Each or linear foot
Impact attenuator service (Type)	Each
Temporary signalization	Lump sum
Construction pavement marking (Type and width)	Linear foot
Construction pavement message marking (Type and message)	Each
Eradication of existing pavement marking	Linear foot

Temporary pavement marker ([]-way)	Each
Temporary detour (Standard and type)	Linear foot
Aggregate material No.	Ton
Type III barricade (width)	Each
Construction signs	Square foot
Truck Mounted Attenuator	Hour

SECTION 704—PAVEMENT MARKINGS AND MARKERS

704.01—Description.

This work shall consist of establishing the location of pavement markings and installing pavement markings, pavement markers, and reflectorized material on specified pavements in accordance with these specifications, the *MUTCD* and as directed by the Engineer.

704.02—Materials.

The Contractor shall use an approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by the following certification:

Material shipped under this certification has been tested and approved by VDOT as indicated by laboratory test numbers listed hereon.

Signature and Title

Date

- (a) **Pavement markings** shall conform to the requirements of Section 246.
- (b) **Glass beads** shall conform to the requirements of Section 234.
- (c) **Pavement markers** shall conform to the requirements of Section 235.

704.03—Procedures.

The Contractor shall have a certified Pavement Marking Technician present during pavement marking operations.

Pavement markings shall be installed on new roadways prior to opening the roadway to traffic. Pavement marking installation shall be completed within the time limits herein on roadways where the pavement markings have been removed or obscured and the roadway is open to traffic unless otherwise directed by the Engineer. Installation of Type B, Class VI pavement markings on asphalt roadways are not applicable to these requirements if they are inlaid with the last pass of the asphalt roller or directly after the asphalt roller utilizing a separate roller.

Installation of edge lines on roadways where the existing pavement markings have been removed or obscured are also required within these time limits unless otherwise indicated by the Engineer. Exceptions to the below time limits will be granted only for weather restrictions, and installation of epoxy resin pavement markings on new pavement shall not commence until after 24 hours of final surface placement.

Pavement marking installation on roads having traffic volumes of 10,000 ADT or more shall be completed within 24 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes between 3,000 and 10,000 ADT shall be completed within 48 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes of less than 3,000 ADT shall be completed within 72 hours after the end of the workday where the pavement markings were removed or obscured.

If the Contractor will not have pavement markings installed within the time limits set above, the Contractor shall install Type D construction pavement markings within the same time limits and maintain such until the final pavement markings can be installed. The cost of installing, maintaining and removing the Type D construction pavement markings shall be borne by the Contractor with no cost to the Department.

When establishing the location of pavement markings, the Contractor may mark the locations on the roadway by installing premarkings. Premarkings shall be accomplished using Type D (removable – any class) tape, chalk, or lumber crayons except special pavement markings such as stop lines, crosswalks, messages, hatching, etc. shall be accomplished using chalk or lumber crayons. All premarkings shall be of the same general color as the pavement markings being premarked. When tape is used as premarking, premarking shall consist of 4-inch x 4-inch maximum squares or 4-inch maximum diameter circles spaced at 100-foot minimum intervals in tangent sections and 50-foot minimum intervals in curved sections. At locations where the pavement marking will switch colors, e.g. gore marking, the ends of the markings may be premarked regardless of the spacing. When

chalk or lumber crayon are used as premarking, the entire length of the pavement marking may be premarked. All premarkings shall be installed whereby its installation shall not affect the adhesion of the pavement markings. When Type D tape is used as the premarking and the lateral location of such premarkings to the final pavement markings exceeds 6 inches, the premarkings shall be removed at no cost to the Department.

- (a) **Pavement Markings:** Pavement markings shall be white or yellow markings as required by the *MUTCD* for the specific location or as specified by the Engineer and shall be installed in accordance with Table VII-1 unless otherwise recommended by the manufacturer and approved by the Engineer. The Contractor shall furnish a copy of the manufacturer's installation recommendations to the Engineer.

The Contractor shall perform quality control testing for application thickness and glass bead rate in accordance with VTM-94 at the beginning of each workday and every 3 hours thereafter. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the quality control testing. Testing shall be performed in the presence of the Engineer.

The Contractor shall maintain a daily log (Form C-85) for both temporary and permanent pavement markings and markers. Entries in the log shall be made in ink, shall be legible, and the log shall be signed by the Contractor and delivered to the Engineer or designee by the end of each workday.

Pavement line markings shall consist of stop lines, crosswalks, and solid or skip lines used for, but not limited to, dividing lanes, marking edges, channelizing, outlining and marking safety zones around objects, and forming islands and parking lot stalls.

TABLE VII-1

PAVEMENT MARKINGS

Type	Class	Name	Surface Temp. at Time of Application	Film Thickness (mils)	Pavement Surface	Application Limits
A	-	Traffic Paint	50 °F+	15 ± 1 when wet	AC HCC	May be applied directly after paving operations
B	I	Thermoplastic Alkyd	50 °F+	90 ± 5 when set	AC	May be applied directly after paving operations
	I	Thermoplastic Hydrocarbon	50 °F+	90 ± 5 when set	AC	Do not apply less than 30 days after paving operations
	II	Polyester resin	50 °F+	15 ± 1 when wet	HCC	Needs to be coned
	III	Epoxy resin	50 °F+	20 ± 1 when wet	AC HCC	Pavement surface needs to be at least a day old
	IV	Plastic-backed preformed tape	Manufacturer's Recommendation	60 - 90	AC HCC	Manufacturer's Recommendations
	VI	Patterned preformed tape	Manufacturer's Recommendation	20 * 65**	AC HCC	Manufacturer's Recommendations
D	I & II	Removable tape	Manufacturer's*** Recommendation		AC HCC	Construction zone pavement marking
E	-	Removable black tape (non-reflective)	Manufacturer's *** Recommendation		AC	Construction zone pavement marking for covering existing markings
F	I & II	Temporary markings	Manufacturer's *** Recommendation (Film Thickness = 40 mils max)		AC HCC	Construction zone Pavement marking

* Thinnest portion of the tapes cross-section. This is the minimum required thickness.

** Thickest portion of the tapes cross-section. This is the minimum required thickness.

*** In the event the manufacturer's recommendation for film thickness is less than utilized when the material was tested by the National Transportation Product Evaluation Program (NTPEP) or other Department approved test facility, the minimum values used during installation shall conform to the test values which are indicated on the approved list for the specific marking.

Crosswalks and stop lines shall be installed using Type B, Class I or IV markings.

Solid lines or skip lines shall be installed using Type A or Type B markings as specified.

Pavement message markings shall be installed using Type B, Class I, IV or VI markings and shall include, but not be limited to, school zone markings, railroad crossing markings, disabled parking symbols, elongated arrows, word messages, etc. The word SCHOOL shall be formed with characters that are 10 feet in height where permitted by the normal roadway width. School zone markings shall extend transversely across both lanes of two-lane roadways and across two or more approach lanes of roadways of three or more lanes. Disabled parking symbols shall be 41 inches in height, 36 inches in width and shall use a 4-inch stroke width for the lines.

The Contractor shall protect the public from damage attributable to pavement marking operations. The Contractor shall be responsible for the complete preparation of the pavement surface, including, but not limited to, removing dust, dirt, loose particles, oily residues, curing compounds, concrete laitance, residues from eradication, and other foreign matter immediately prior to installing pavement markings. The pavement surface shall be dry at the time of installation when tested in accordance with VTM-94. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the moisture test. Marking material shall not be applied within 24 hours following rain or other inclement weather.

Liquid markings shall be applied so as to prevent splattering and overspray and shall be protected from traffic until track free by the use of guarding or warning devices as necessary. If a vehicle crosses a marking and tracks it or if splattering or overspray occurs, the affected marking and resultant tracking shall be removed and new markings applied at the Contractor's expense.

Equipment shall also be thoroughly cleaned between changes in colors of materials.

Pavement markings shall have clean and well-defined edges without running or deformation; shall be uniform, free of waviness; shall be straight on tangent alignment; and shall be on a true arc on curved alignment. The widths of pavement markings shall not deviate more than $\frac{1}{4}$ inch on tangent nor more than $\frac{1}{2}$ inch on curves from the required width. The length of the gap and the length of the individual stripes that form skip lines shall not deviate more than two inches. The length of the gap and individual skip line shall be of such uniformity throughout the entire length of each that a normal striping machine will be able to repeat the pattern and superimpose additional striping upon the existing marking.

Glass beads shall be applied at the rate specified herein and shall be evenly distributed over the entire surface of the marking. Beads shall be applied to the surface of liquid markings by a bead dispenser attached to the applicator that shall dispense beads simultaneously

on and in the just-applied marking. The bead dispenser shall be equipped with a cut-off control synchronized with the cut off of the applied marking material so that the beads are applied totally to the completed line. Beads shall be applied while the liquid marking is still fluid. Approximately 70 percent of beads shall be buried in the marking, and the remaining 30 percent shall be 50-60 percent embedded in the surface. Beads installed on crosswalks and stop lines on roadways with curbs only (no gutter) may be hand applied for two feet at the end of each line next to the curb with 100 percent of the beads embedded 50-60 percent in the surface.

Markings found to be unacceptable shall be removed, and new markings applied at the Contractor's expense.

1. **Type A markings:** Paint may be applied to asphalt concrete and hydraulic cement concrete pavements. Paint shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Paint may be applied over existing paint markings.

Paint shall be applied with a line painting machine that is capable of hot spraying paint directly onto the pavement surface with a uniformity of feed through its nozzles for widths of 4 through 8 inches. The machine shall be capable of applying two pavement stripes, either solid or skip, at the same time when double line markings are required. Paint tanks on the equipment shall be equipped with a mechanical agitator and paint shall be thoroughly mixed and heated such that it will not track within 60 seconds after its application.

Non-truck mounted equipment shall be self-propelled and regulated to allow for calibration of the amount of material applied.

Glass beads shall be applied to the surface of the paint at the rate of 6 pounds per gallon of paint.

2. **Type B markings:**

Equipment shall be capable of providing mixing, heating and agitation of material. Material shall be uniformly heated throughout the system in accordance with the manufacturer's recommendations. Thermoplastic material shall be maintained in the heating kettle and applied to the road surface at a minimum temperature of 400 degrees F. Heating kettles shall be equipped with an automatic thermostatic control device. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the actual temperature of molten thermoplastic material. Multi-component material shall be applied using internally injected guns for the mixing of catalyst and hardener.

Non-truck mounted equipment for application of thermoplastic material shall be of the screed extrude type with a screw drive or shall be self-propelled and regulated to allow for calibration of the amount of material applied. Non-truck mounted equipment for

application of polyester and epoxy resin material shall be self propelled and regulated to allow for calibration of the amount of material applied.

- a. **Thermoplastic (Class I)** material shall only be applied on asphalt concrete pavements and shall be applied by screed extrude, ribbon gun or spray equipment. Alkyd thermoplastic may be applied directly after the paving operations, however hydrocarbon thermoplastic shall not be applied less than 30 days after the paving operations.

Alkyd and hydrocarbon materials shall not be mixed together. Equipment shall be thoroughly cleaned before types of material are changed.

Thermoplastic shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Thermoplastic may be applied over existing thermoplastic markings. For concrete bridge decks that occur in asphalt roadways, Type B, Class VI tape shall be used.

Primer/adhesive shall be applied to asphalt concrete surfaces more than two years old and shall be from the same manufacturer as the thermoplastic.

Glass beads shall be applied to the surface of the marking at the rate of 7 pounds per 100 square feet.

- b. **Polyester resin (Class II)** material shall only be applied on hydraulic cement concrete pavements. Polyester resin shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Polyester resin may be applied over existing polyester resin markings.

Glass beads shall be applied to the surface at the rate of 8 pounds per gallon of material.

- c. **Epoxy resin (Class III)** material shall only be applied to asphalt concrete pavement more than one day old and hydraulic cement concrete pavement. Epoxy resin shall not be applied over existing pavement markings unless the existing marking is 90 percent removed.

Glass beads shall be applied by the gravity method to the surface at the rate of 25 pounds per gallon of material.

- d. **Plastic-backed preformed tape** shall be installed in accordance with the manufacturer's recommendations and as denoted herein. Tape may be applied to asphalt concrete and hydraulic cement concrete pavements. Tape may be installed immediately following the final rolling of the new asphalt concrete surface. Tape shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed.

Primer/adhesive shall be used for all installations except when tape is applied immediately following the final rolling of the new asphalt concrete surface and shall be from the same manufacturer as the tape.

Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with the weight as recommended by the manufacturer. The use of a vehicle to ride over the markings for tamping will not be permitted.

(b) Eradication:

Eradication of pavement markings for restriping when required shall be in accordance with Section 512 except only 90 percent removal of the existing markings is required.

(c) Pavement Markers:

1. **Snow-plowable raised pavement markers** shall be installed by cutting two parallel grooves into the pavement at the depth and dimensions recommended by the manufacturer. Grooves shall be parallel to the adjacent pavement marking. Grooves shall be cut with saw blades having a diameter to match the curvature of the steel casting bottom and keels. Keel surfaces shall be free from scale, dirt, oil, grease, or any other contaminant that might reduce bonding.

Casting keels shall be bonded in the saw-cut grooves in the manner recommended by the manufacturer of the marker. The bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker. Noses of the casting shall be installed flush with the pavement surface. The installed height of the raised pavement marker shall be approximately 1/2 inch above the pavement surface. Ambient temperature at the time of installation of the snow-plowable raised pavement markers shall be at least 50 degrees F or higher.

The top of reflectors shall be mounted flush with the top of the casting.

2. **Raised pavement markers** shall be bonded to the pavement surface in accordance with the manufacturer's recommendations. Bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker except epoxy shall not be used on asphalt concrete pavements.

704.04—Measurement and Payment.

Pavement line markings will be measured and paid for at the contract unit price per linear foot. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement message markings will be measured and paid for at the contract unit price per each per location. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement markers will be measured and paid for at the contract unit price per each. This price shall include prismatic retroreflectors, pavement cutting, adhesive, and castings.

Eradication of pavement markings will be measured and paid for in accordance with Section 512.

Payment will be made under:

Pay Item	Pay Unit
Pavement line marking (Type and/or class and width)	Linear foot
Pavement message marking (Message)	Each
Pavement marker (Type, []-way, and/or type pavement)	Each