Appendix D
Answers To Chapter Review Questions

Chapter 1
Standard Practices

1. The purpose of pavement markings is to communicate information about the traveled roadway so motorists can safely reach their destination.
   a) True

2. Standard markings shall only be used to convey the meaning prescribed for them in the Manual on Uniform Traffic Control Devices (MUTCD).
   a) True

3. In Virginia, the normal specified width of a longitudinal line is:
   b) 4 – 6 inches

4. The standard for a broken line separating traffic in the same direction at the same speed limit is:
   c) 10 ft. segments with 30 ft. gaps.

5. Solid yellow lines are used to delineate the separation of traffic flows in:
   a) opposing directions.

6. The left edge of divided highways and one way roads is delineated by:
   d) a single solid yellow line.

7. White lines are used to delineate the separation of traffic flows in:
   b) the same direction.

8. The right edge of divided highways and one way roads is delineated by:
   c) a single solid white line.
9. Broken lines are restrictive in nature.
   b) False

10. Solid lines are restrictive in nature.
   a) True

11. A double line consists of two normal width lines separated by a 3 inch space.
   b) False

12. A pavement marking plan or sketch may not be required before a road is marked, but is strongly encouraged.
   a) True

13. A chalk line is the only approved way of pre-marking a road.
   b) False

14. Traffic control is not required when pre-marking on low volume roads.
   b) False

15. Which document takes precedence over all others:
   c) Special Provision Copied Notes

16. In the Road and Bridge Specifications Book, which section specifies that the publication, “Quality Standards for Workzone Traffic Control Devices” be used?
   c) Section 512
1. Reflective beads are used with pavement markings:
   c) to enhance nighttime visibility

2. The phenomenon where light is reflected directly back to the light source is called:
   b) retroreflectivity

3. For glass beads, the light bending phenomenon is known as:
   a) the refractive index

4. The optimum embedment depth for reflective beads is
   b) 50 to 60%

5. When inspecting pavement markings with regard to glass beads, which of the following criteria should be met?
   c) Both a & b

6. In order for glass beads to reflect light as intended, they must be:
   d) round

7. Proper bead distribution and depth are critical in ensuring a __________ line.
   a) durable and retroreflective

8. Correct glass bead application and embedment will result in the line feeling like:
   c) sandpaper
Chapter 3
Traffic Paint

1. VDOT designated “Type A” traffic paint should dry “track-free” within:
   c) 60 seconds

2. Reflective beads are normally:
   b) spray applied to the wet paint immediately following application of the marking material.

3. The minimum surface temperature at which Virginia designated Type A traffic paint may be applied is:
   c) 50 °F +

4. Before marking materials of any kind may be applied, the surface of the roadway must be:
   c) both a & b

5. The specified application thickness for Virginia designated Type A traffic paint is:
   c) 15 ±1 mil when wet

6. The minimum amount of glass beads applied to Type A paint is:
   a) 6 pounds per gallon
Chapter 4
Liquid Thermoplastic

1. Liquid thermoplastic pavement marking material:
   a) is a blend of solid materials that becomes liquid when heated.

2. Markings constructed with liquid thermoplastic pavement marking materials are considered:
   a) durable markings.

3. Liquid thermoplastic comes from the manufacturer with reflective beads already intermixed.
   a) True

4. Reflective beads have to be applied to liquid thermoplastic pavement markings.
   a) True

5. Granular thermoplastic may be heated three (3) times.
   a) True

6. Block thermoplastic may be heated three (3) times.
   b) False

7. It is permissible to intermix alkyd and hydrocarbon thermoplastic materials in the same heating kettle.
   b) False

8. Which of the following methods are acceptable for applying thermoplastic?
   d) all of the above
9. Virginia Road & Bridge Specifications requires the thickness of thermoplastic markings to be:

   b) 90 ± 5 mils when set

10. Virginia specifies that glass beads be applied to liquid thermoplastic immediately and uniformly across the entire line at the rate of:

    a) 7 lb/100 ft²
1. There is no need to add glass beads to newly applied preformed thermoplastic since they are intermixed with the material at the factory.
   c) False

2. When stored inside at a temperature between 35ºF and 95ºF, preformed thermoplastic has a shelf life of .
   c) 1 year

3. Preformed thermoplastic is considered to be a:
   a) durable pavement marking

4. When preformed thermoplastic has been positioned on the pavement, it is necessary to heat only the edges of the material to achieve a good bond with the pavement.
   b) False

5. When a small portion of freshly applied preformed thermoplastic has been chiseled up to inspect for bonding with the pavement, it should ________________ on the underside.
   b) have some asphalt stuck to it
Chapter 6
Epoxy Resins

1. Epoxy pavement marking material:
   a) is a two component system.

2. Epoxy pavement marking material does not contain solvent.
   a) True

3. For epoxy pavement markings, the ratio of resin to hardener is:
   d) all of the above

4. The Virginia specified thickness for epoxy pavement markings is:
   c) 20 ± 1 mil when wet

5. The equipment used to apply epoxy resin pavement markings cannot be used to apply any other liquid binder material.
   a) True

6. The minimum surface temperature for applying epoxy markings in Virginia is:
   c) 50 °F +

7. Glass beads should be applied to the surface of epoxy resin at the rate of:
   b) 25 pounds per gallon
Chapter 7
Polyurea Resin

1. What is one advantage for using Polyurea pavement marking material?
   a) Good abrasion resistance.

2. Polyurea pavement marking material is normally applied at the following thickness:
   b) 20 mils

3. Polyurea pavement marking material cure time is less than one minute.
   a) True

4. What is the sheet called where manufacturer’s product information is found for polyurea application requirements?
   c) Product Data Sheet (PDS)

5. Polyurea is typically applied at a 20 mil wet film thickness and will yield a 20 mil dry film thickness after curing.
   a) True
Chapter 8
Preformed Tape

1. Preformed tapes do not contain pigments.
   b) False

2. Preformed pavement marking tapes can be used for:
   c) both a & b

3. When patterned tape is inlaid, no primer is used.
   a) True

4. Glass beads are applied to pavement marking tapes:
   c) by the manufacturer

5. The minimum surface temperature at which pavement marking tapes may be applied is:
   d) as recommended by the manufacturer

6. Virginia specifications allow pavement marking tapes to be tamped with vehicle tires.
   b) False

7. Virginia Road & Bridge specifications state that the contractor is responsible for supplying a copy of the manufacturer’s installation recommendations to the project inspector.
   a) True

8. Virginia designated Type E tape is:
   c) black
Chapter 9
Pavement Markers

1. Pavement markers may be used in lieu of pavement markings.
   b) False

2. The most common types of pavement markers are:
   d) all of the above

3. Raised temporary pavement markers are glued to the roadway with a bitumen or epoxy adhesive.
   a) True

4. Raised temporary pavement markers are normally used with:
   b) construction zone markings.

5. Raised snow plowable marker castings are installed using bitumen adhesive.
   b) False
Chapter 10
Installation & Quality Control

1. VDOT requires that by the end of each workday, form C-85, “Contractor’s Daily Log and Quality Control Report”, shall be signed by the Contractor and delivered to the:
   c) Engineer or VDOT Inspector

2. VDOT specs. state that before proceeding with work, surface temperature and weather conditions must be checked for compliance with the specifications by the:
   b) contractor’s certified Q.C. technician

3. Layouts for pavement markings must be in conformance with:

4. VDOT requires that quality control tests be conducted in accordance with:
   d) VTM-94.

5. What topics should be discussed at the pre-construction conference held prior to beginning pavement marking operations?
   d) all of the above

6. A copy of the manufacturer’s recommended installation instructions for pavement marking tapes does not have to be supplied by the contractor.
   b) False

7. A Material Safety Data Sheet (MSDS) must be obtained by the contractor for each material required for a particular type of pavement marking.
   a) True

8. In Virginia, traffic control must be constantly monitored to minimize disruption and to ensure compliance with:
   e) a and c
9. The contractor is required to measure the application thickness and bead application rate:
   b) at the beginning of each workday and every three hours thereafter.

10. Both the contractor and the inspector should constantly monitor the installation and quality
    of the material being placed.
    a) True

11. In addition to application rates and glass bead distribution, markings should be inspected
    with regard to:
    d) all of the above

12. VDOT requires in order that corrective action be taken, the inspector should immediately
    report unacceptable work to:
    c) the contractor.

13. When should pay quantities be compared and confirmed by the contractor and inspector?
    b) at the end of each operation or the end of each workday

14. Before beginning work, the Source of Materials Document is required to insure that:
    d) all of the above

15. VDOT specifications require the Materials Inventory Tracking system to be maintained by
    the:
    a) contractor

16. The contractor’s inventory is monitored by the:
    a) Central Office Materials Quality Assurance Section

17. Copies of materials certifications are to be retained by the contractor as part of the Materials
    Inventory Tracking documentation.
    a) True
18. When materials are delivered directly from the manufacturer to a VDOT project, the project inspector will contact:
   
   b) Central Office Materials Quality Assurance Section

19. Contractor’s Daily Log and Quality Control Report is required on Federal Projects only.
   
   b) False
Chapter 11
Equipment

1. A long-line paint truck manufactured by one company should look exactly the same as that of a different manufacturer.
   b) False

2. Which item mentioned below is a component for a long-line truck?
   d) all of the above

3. The inspector should be knowledgeable with the pavement marking equipment to help identify problems.
   a) True

4. Clear communication and cooperation between the inspector and contractor helps ensure quality.
   a) True

5. One must inspect pavement marking “close up” to ensure quality.
   a) True
Chapter 12
Eradication

1. Failure to remove existing markings when there are shifts in the traffic pattern can:
   d) all of the above

2. Which of the following methods is not acceptable for long term eradication?
   e) both b and c

3. All residue created when eradicating pavement markings must be:
   b) contained.

4. Eradication methods, other than those specified, must be submitted to the project engineer for approval prior to beginning work.
   a) True

5. Eradicated lines should be inspected for:
   c) both a & b

6. Virginia designated Type E black tape may only be used on hydraulic cement concrete roadways.
   b) False

7. One of the criteria in Virginia for using Type E black tape in lieu of eradication is that the traffic pattern will shift back to the original pattern within:
   c) 120 days.
Appendix E

Metric Conversion Information SI Metric

SI Metric stands for “Le Systeme International d’Unites”, which means “The International System of Units”. The metric system is a decimal-based system, a system in which units are related to each other in factors of ten. Our money system is a decimal based system. A penny is one-hundredth of a dollar.

The following metric units will be used by pavement marking crews:

**Meters (m)** - A meter is approximately the length of an outstretched arm from the fingertips to the shoulder of the other arm.

**Kilometers (km)** - The metric prefix kilo means one thousand. A kilometer is one thousand meters.

**Millimeter (mm)** - The prefix milli means divided by a thousand. A millimeter is one thousandth of a meter.

**Centimeter (cm)** - The centimeter is the measurement of length that is one hundredth of a meter.

0.001 kilometer = 1 meter = 100 centimeters = 1000 millimeters

**Kilogram (kg)** - The metric unit for measuring mass.

**Liter (L or l)** - The metric unit for measuring fluid volume.

**Degrees Celsius** - The temperature scale in the Celsius system is determined as follows: The temperature at which water freezes is marked at 0 degrees Celsius. The temperature at which water boils is 100 degrees Celsius. The difference between these two points is divided into 100 equal parts. On a Fahrenheit scale water freezes at 32 degrees and boils at 212 degrees.

**Micron** – The prefix micro means divided by one million. A micron is one millionth of a meter.
Try estimating measures and dimensions directly in SI units. Even if your estimates are not correct, continue trying. With every estimate you will be a step closer to “thinking metric”.

### CONVERSION ENGLISH TO METRIC

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<th>To Obtain</th>
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</thead>
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<td>Meters</td>
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<td>Square feet</td>
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<td>Inches</td>
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<td>Microns</td>
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Degrees C = 5/9 (F - 32)

### CONVERSION METRIC TO ENGLISH

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<th>To Obtain</th>
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<td>square feet</td>
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<td>Microns</td>
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<td>Inches</td>
</tr>
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</table>

Degrees F = (9/5 x C) + 32
**Example Problem:** How many meters are there in 2.50 yards?

\[ 2.50 \times 0.9144 = 2.286 \text{ meters} \]

**PRACTICE PROBLEMS**

1) If 50 gallons of yellow traffic paint are loaded on the truck, how many liters does this equal?

2) 950 linear feet of traffic tape was placed starting at station 1528+00, how many meters were placed?

3) Convert the following to metric:
   
   12 lbs. yellow thermoplastic
   
   120 yards tape

4) A contract calls for 25,250 linear feet of tape. How many meters is this?

5) Convert the following to English units:
   
   0.34 kilograms of reflective beads
   
   600 millimeters of stop line marking

6) The surface temperature at time of application of thermoplastic must be 10 degrees Celsius and rising. What is this in degrees Fahrenheit?
Appendix F

Proficiency Checklists

1. Test for Moisture in Pavement Prior to Application of Liquid Markings
2. Test for Moisture in the Pavement with Thermoplastic Application
3. Wet Film Thickness of Liquid Marking Materials
4. Test for Determining the Film Thickness for Thermoplastic Markings
5. Test for Determining Application Rate of Glass Beads – Method 1
6. Visual Inspection
<table>
<thead>
<tr>
<th>Test for Moisture in Pavement Prior to Application of Liquid Markings</th>
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</thead>
<tbody>
<tr>
<td><strong>Equipment needed:</strong></td>
</tr>
<tr>
<td>Minimum size 6” x 6” plastic</td>
</tr>
<tr>
<td>Duct tape</td>
</tr>
<tr>
<td><strong>Procedure:</strong></td>
</tr>
<tr>
<td>1. Select a location representative of the pavement surface where markings are to be applied.</td>
</tr>
<tr>
<td>2. Secure all edges of the plastic to the pavement surface with the duct tape.</td>
</tr>
<tr>
<td>3. After a period of time (20 minutes recommended), check for condensation of moisture on the under side of plastic.</td>
</tr>
</tbody>
</table>
# Test for Moisture in the Pavement with Thermoplastic Application

## Equipment Needed:
- #15 Tar paper
- Duct tape

## Procedure:
1. Select a location where markings are to be applied.
2. Place the tar paper on the pavement surface and secure the tar paper to the surface with duct tape such that it will not be displaced when the thermoplastic is applied.
3. Apply the thermoplastic to the tar paper.
4. Wait approximately one (1) minute to allow any moisture in the pavement to condense onto underside of the tar paper.
5. Carefully remove the tar paper from the pavement.
6. Inspect the underside of the tar paper for condensation of moisture.
### Test for Determining the Wet Film Thickness of Liquid Marking Materials

Verify the thickness of all liquid pavement marking materials, except thermoplastic, immediately following application.

#### Equipment needed:
- Calibrated wet mil thickness gauge
- Sample plate (sheet metal - 4”x 6”, 20 to 40 mils thick)*
  *Thickness must be maintained: thinner plate will deform while taking readings, thicker plate will alter distance between gun and pavement. Both result in false readings.
- Piece of cloth
- Duct Tape

#### Procedure:
1. Select a level location in the path of where the markings are to be applied.
2. Place the plate on the pavement surface and secure it with duct tape.
3. Apply the marking material to the sample plate using the equipment being evaluated.
4. Make sure the glass bead gun is turned off prior to applying the marking material to the sample plate.
5. Immediately after application, place the gauge into the material on the sample plate until the posts on the gauge are firmly in contact with the plate. The gauge is configured such that the probes indicate a thickness from a line drawn between the posts. The last probe with material on it indicates the thickness.
6. Read the thickness from the gauge.
7. Gauge should be cleaned with a cloth immediately after taking reading.
## Determining the Film Thickness for Thermoplastic Markings

### Equipment needed:
- Calipers accurate to .001 inch
- Sample plate (sheet metal – 4” x 6”, 40 to 60 mils thick)
- Duct tape

### Procedure:
1. Measure and record the thickness of the sample plate.
2. Select a location in the path of where the markings are to be applied. Place the plate on the pavement surface and secure it with duct tape.
3. Make sure the glass bead gun or dispenser is turned off prior to application of the marking material to the sample plate.
4. Apply the marking material to the sample plate using the equipment being evaluated.
5. Wait until the sample cools sufficiently to be moved without flowing. Carefully remove the sample plate from the pavement.
6. Using calipers, measure the total thickness of the thermoplastic and the sample plate.
7. Subtract the panel thickness from the total thickness to obtain the thickness of the applied material.

<table>
<thead>
<tr>
<th>Total thickness of material and panel</th>
<th>Thickness of the panel</th>
<th>Thickness of the thermoplastic</th>
</tr>
</thead>
</table>
Test for Determining Application Rate of Glass Beads - Method 1

<table>
<thead>
<tr>
<th>Equipment needed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrated 1 gallon bucket.</td>
</tr>
<tr>
<td>Stop watch or watch with second hand</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Determine the time required to dispense the specified quantity of beads from Table 1. Find vehicle speed. Go to column on right for time needed to dispense 6 lbs. of beads.</td>
</tr>
<tr>
<td>2. Position the bucket under the bead gun such that all beads dispensed will be caught in the bucket.</td>
</tr>
<tr>
<td>3. Turn on the bead gun for the time increment from Table 1 (The pressure must be at the same setting that is used while applying markings.)</td>
</tr>
<tr>
<td>4. Compare the level of beads in the bucket with the appropriate graduation.</td>
</tr>
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</table>

If there is a difference of 1/2 inch or greater between the level of the beads and the calibration mark in the bucket what would you do?

Make adjustments to the equipment to close this gap.

How is bucket calibrated?

Pour 6 pounds of glass beads into bucket and mark depth on bucket by using indentions, drilled holes or marks. Then add 1 pound increments of beads, marking on side of bucket after each addition.

<table>
<thead>
<tr>
<th>Vehicle Speed mph</th>
<th>Time to Dispense Specified Quantity of Glass Beads (seconds)</th>
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<tbody>
<tr>
<td>4</td>
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<tr>
<td>5</td>
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<td>18</td>
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Visual Inspection
Knowing material quantities does not assure that everything was distributed correctly. This procedure provides guidelines for the visual inspection of pavement markings. Markings which do not meet the criteria stated below, fail this procedure and should be rejected.

Visual inspections are made with regard to one of two (2) items: the marking itself or the glass beads.

1) **The Marking**
   a) The location of markings should be compared with the plans and/or the Manual of Uniform Traffic Control Devices (MUTCD). Markings that do not conform to these requirements are unacceptable.
   b) Markings must be of the specified width.
   c) Markings must be checked for even thickness. This may be done by either inspecting the samples taken for thickness measurements or viewing the marking directly on the pavement. With either method, look for uneven thickness in the cross-section of the marking.

2) **The Glass Beads**

Visual inspection of glass bead application is either with regard to distribution or embedment

**Distribution**
   a) Beads should cover the entire marking.
   b) Beads should be evenly distributed across the entire marking.
   c) All beads should either be embedded into or onto the marking with little or no loss onto the adjacent pavement.

**Embedment**
   a) Visual evaluation of bead embedment should be made on the marking after application to the road surface. The specifications for bead embedment are general. It is not feasible to obtain exact percentages of buried vs. non-buried beads.

Generally, a marking that fails the visual inspection for bead embedment exhibits one of the following conditions:

1) Most or all the beads are buried in the marking material.
2) Beads are insufficiently buried (most or all beads are on the surface of the marking).
3) “Pulsed” beads - This is caused by rapid fluctuations in the delivery of the beads to the gun.
4) Most or all beads are on one side of the marking.
BIBLIOGRAPHY

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   Written by: Frank L. Dray
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   Director of Research
   Potters Industries, Inc.
   Hasbrouck Heights, N.J.