Pavement Marking Selection, Installation and Inspection Manual

State of Illinois
Illinois Department of Transportation

Illinois Department of Transportation

2014-0131, 0346-15, 10/14, web

Prepared and Published by
Illinois Department of Transportation
Bureau of Materials and Physical Research
Bureau of Operations

Springfield Illinois

August 1, 2015
Continually
Updated Resource

DOCUMENT CONTROL

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Date	Revision Date	Description of Change	Authorized By
08/01/15	08/01/15	Original Edition	Kelly Morse
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Purpose

This manual serves as both a reference for selecting optimum marking materials and as a reference for inspecting the installation of markings. The manual is intended for use in design, maintenance, and inspection.

History

This manual is a product of an Illinois Center for Transportation (ICT) research project. The project, ICT R27-77, "Evaluating Pavement Markings on Portland Cement Concrete and Various Asphalt Surfaces," was conducted by Applied Research Associates, Inc. (ARA) and guided by a Technical Review Panel (TRP) consisting of members of the Illinois Department of Transportation (IDOT), the Illinois Tollway, and industry. A copy of the final report can be found on the ICT website: http://www.ict.illinois.edu (click on the "Research" tab at the top of the page, then from the drop-down menu, select "Publications" and search for project R27-077).

Disclaimer

This is a new manual and does not replace any existing documents. The manual does not constitute a standard, specification, or regulation.

Contact

Questions concerning information in the manual should be addressed to the Bureau of Materials and Physical Research (BMPR) at 217-782-7218 or the Bureau of Operations at 217-782-7414.

Contents

SECTION 1 INTRODUCTION

Pavement markings provide critical information to motorists. With the wide variety of marking materials available, choosing the material that best meets the needs of the public can be challenging. The purpose of this manual is to serve as a reference for selecting optimum pavement marking materials for different site criteria. Optimum marking materials are those that are compatible with the site, provide an appropriate service life, and are cost effective. Section 2 of the manual describes the various factors that influence the performance of pavement markings and then, based on these variables, presents matrices of recommended materials.

Because the successful performance of a marking depends on proper installation, section 3 is included as a reference for inspecting the installation of markings. That section contains installation inspection checklists for each of the marking types approved by the Illinois Department of Transportation (IDOT) at the time of this manual's publication. Currently approved marking materials and their performance criteria are described in IDOT's Standard Specifications for Road and Bridge Construction.

This manual is intended for use by design personnel, maintenance personnel, and field inspectors. It provides a single reference for all personnel so that the benefits from pavement marking research and best practices can be standardized across the state.

SECTION 2 MATERIAL SELECTION

2.1 Performance Factors

Many different materials can be used for pavement markings, and the service life and cost of the materials vary greatly. Some materials are more appropriate for a given location than other materials, and the performance of a pavement marking material can vary widely based on many factors. Installation factors that influence performance are covered in section 3, and major factors that affect performance post-installation are:

- Environmental conditions
- Roadway surface type
- Traffic volume

The greatest factor affecting the performance of pavement markings in Illinois is abrasion from snow removal. This is evidenced by the fact that markings in the northern part of the state deteriorate more rapidly than those in the southern part of the state. Illinois is more than 380 miles long from its northern border to its southernmost tip, and because of this range in latitude, the amounts of snowfall vary considerably. Figure 1 is a contour map displaying the average number of days with snowfall at or above 1 inch in Illinois. Many regions of the country with heavy snowfall choose to recess pavement markings (place them in shallow grooves) to keep snowplow blades off the markings. Installing the groove is an added expense, but the extended life of the marking often offsets the cost of the groove.

The pavement surface type, hot-mix asphalt (HMA) or Portland cement concrete (PCC), can affect the bonding characteristics of marking materials. Therefore, markings can have different service lives depending on the surface on which they are placed.

Traffic volume can also influence the performance of a pavement marking. The service lives of pavement marking materials decrease when exposed to higher traffic volumes. For this reason, more durable markings are often considered for roadways with higher average annual daily traffic (AADT).

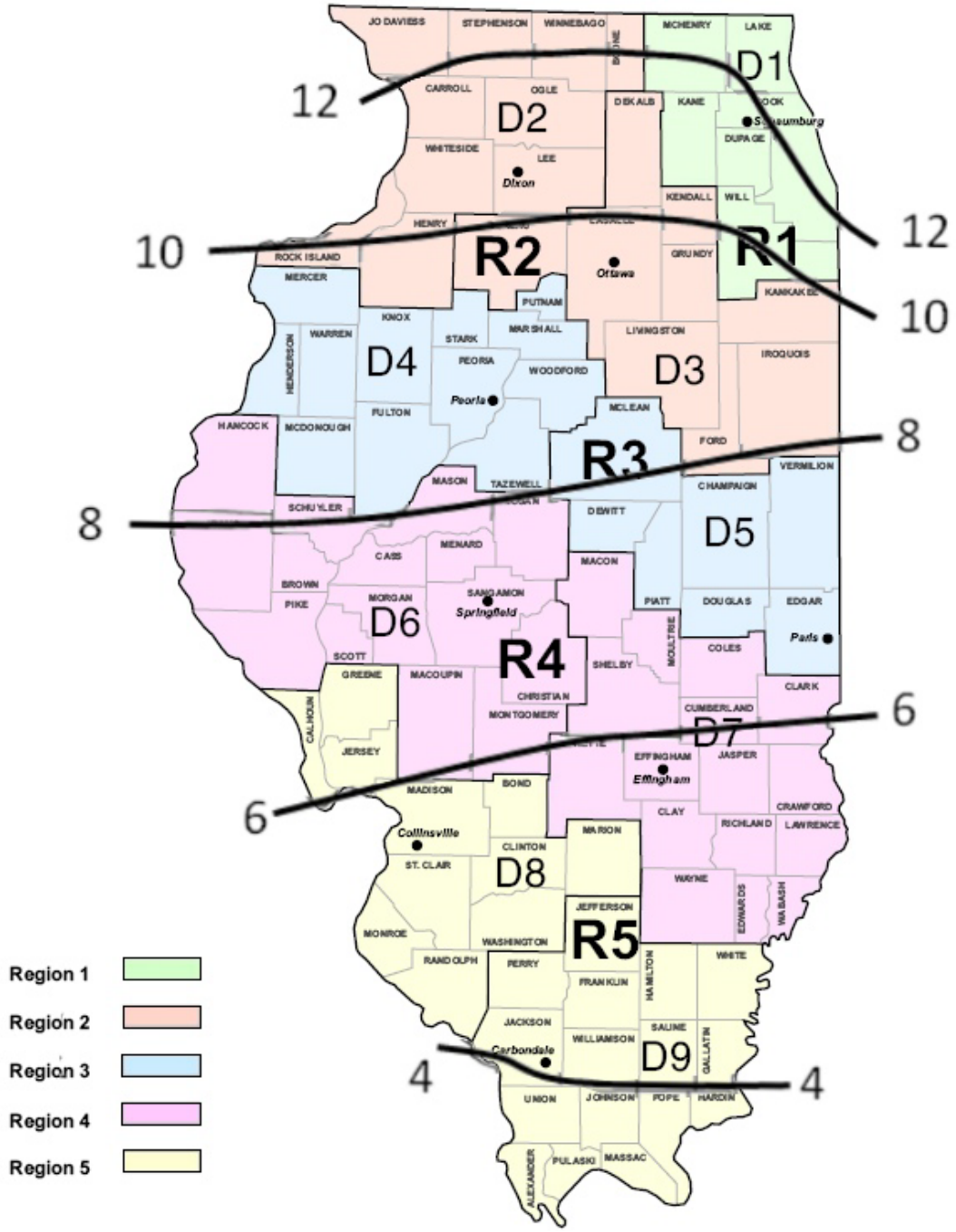

Figure 1. Average number of days with snowfall at or above 1 inch.

2.2 Material Recommendations

Because of the varied environmental conditions in Illinois, the recommendations in this manual separate the state into three climatic zones: Northern, Central, and Southern. The Northern Zone includes areas north of Interstate 80, which closely follows the contour line in Figure 1 for 10 days per year at or above 1 inch of snowfall. The Central Zone is the area between Interstate 80 and Interstate 70, which closely follows the contour line for 6 days at or above 1 inch of snowfall. The Southern Zone is the area of the state south of Interstate 70.

At the time of this manual's publication, the IDOT-approved permanent pavement marking materials for long line application were:

- Thermoplastic
- Water-based paint
- Preformed plastic (tape), Type B
- Epoxy
- Polyurea
- Modified urethane

New materials and formula modifications to existing materials frequently become available. Therefore, such materials may be used on an experimental basis with approval from the Bureau of Materials and Physical Research (BMPR).

When considering marking materials for maintenance striping (restriping), it is important to note that not all material types are compatible with one another. Some materials will adhere to existing materials of another type, and others will adhere only to existing materials of the same type. When a marking is not compatible as the restripe material, then the existing material must be removed. Even when marking materials are compatible, the existing material must still be bonded well to the pavement; loose material should be removed during surface preparation. Table 1 summarizes the compatibility of marking materials for maintenance striping.

Table 1. Matrix of marking material compatibility for restriping.

Existing Material	Restripe Material					
	Thermoplastic	Water-Based Paint	Preformed Plastic, Type B	Epoxy	Polyurea	Modified Urethane
Thermoplastic	Y	Y	N	N	N	N
Water-Based Paint	N	Y	N	N	N	N
Preformed Plastic, Type B	N	N	N	N	N	N
Epoxy	N	Y	N	Y	N	N
Polyurea	N	Y	N	N	Y	N
Modified Urethane	N	Y	N	N	N	Y

Marking material recommendations are presented in Tables 2 through 5. Tables 2 and 3 are material options for maintenance striping on HMA and PCC pavements, respectively. Tables 4 and 5 are options for markings on newly constructed HMA and PCC, respectively. Within each block of the tables, the highest recommended material is listed first. Recommendations are based on expected service life and contracted cost of installation. In parentheses following each material type is the expected service life (in years) and the equivalent uniform annual cost of the material. This information is not intended to be a requirement, but rather to aid users in their selection decisions. The guidelines listed in Departmental Policy TRA-14 for each material type should still be followed. IDOT maintenance crews annually perform a portion of paint maintenance striping, and users should note that the installed cost of these in-house markings may cost less than the contracted costs shown in Table 2.

Table 2. Pavement marking material recommendations for maintenance striping on HMA.

MAINTENANCE STRIPING ON HMA					
Zone	AADT	Pavement Service Life ≤ 5 years [1]		Pavement Service Life > 5 years	
		Surface	Recessed [2]	Surface	Recessed [2]
Northern IL	Low (≤ 7000)	Paint (1-2, $0.20-$0.10)	Urethane (5, $0.11)	Paint (1-2, $0.20-$0.10)	Urethane (5-6, $0.11-$0.10)
		Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (5, $0.14)	Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (6-7, $0.12-$0.10)
	High (> 7000)	Paint (1-2, $0.20-$0.10)	Urethane (5, $0.11)	Paint (1-2, $0.20-$0.10)	Urethane (5-6, $0.11-$0.10)
		Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (5, $0.14)	Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (6-7, $0.12-$0.10)
		Urethane (2-3, $0.27-$0.18)	Epoxy (5, $0.19)	Urethane (2-3, $0.27-$0.18)	Polyurea (7-9, $0.15-$0.12)
		Polyurea (3-4, $0.33-$0.25)	Polyurea (5, $0.20)	Polyurea (3-4, $0.33-$0.25)	Epoxy (6-8, $0.16-$0.13)
		Epoxy (2-3, $0.47-$0.31)		Epoxy (2-3, $0.47-$0.31)	
Central IL	Low (≤ 7000)	Paint (1.5-2, $0.13-$0.10)	Urethane (5, $0.11)	Paint (1.5-2, $0.13-$0.10)	Urethane (6-7, $0.10-$0.08)
		Thermoplastic (4-5, $0.17-$0.14)	Thermoplastic (5, $0.14)	Thermoplastic (4-5, $0.17-$0.14)	Thermoplastic (6-8, $0.12-$0.09)
	High (> 7000)	Thermoplastic (4-5, $0.17-$0.14)	Urethane (5, $0.11)	Thermoplastic (4-5, $0.17-$0.14)	Urethane (6-7, $0.10-$0.08)
		Urethane (3-4, $0.18-$0.14)	Thermoplastic (5, $0.14)	Urethane (3-4, $0.18-$0.14)	Thermoplastic (6-8, $0.12-$0.09)
		Paint (1-2, $0.20-$0.10)	Epoxy (5, $0.19)	Paint (1-2, $0.20-$0.10)	Epoxy (7-9, $0.14-$0.11)
		Epoxy (3-4, $0.31-$0.24)	Polyurea (5, $0.20)	Epoxy (3-4, $0.31-$0.24)	Polyurea (7-9, $0.15-$0.12)
		Polyurea (3-4, $0.33-$0.25)		Polyurea (3-4, $0.33-$0.25)	
Southern IL	Low (≤ 7000)	Paint (1.53, $0.13-$0.07)	Urethane (5, $0.11)	Paint (1.5-3, $0.13-$0.07)	Urethane (6-8, $0.10-$0.07)
		Thermoplastic (5-, $0.14)	Thermoplastic (5, $0.14)	Thermoplastic (5-6, $0.14-$0.12)	Thermoplastic (7-9, $0.10-$0.08)
	High (> 7000)	Paint (1.53, $0.13-$0.07)	Urethane (5, $0.11)	Paint (1.53, $0.13-$0.07)	Urethane (6-8, $0.10-$0.07)
		Thermoplastic (5-, $0.14)	Thermoplastic (5, $0.14)	Thermoplastic (5-6, $0.14-$0.12)	Thermoplastic (7-9, $0.10-$0.08)
		Urethane (4-5, $0.14-$0.11)	Epoxy (5, $0.19)	Urethane (4-5, $0.14-$0.11)	Polyurea (8-10, $0.13-$0.11)
		Polyurea (4-5, $0.25-$0.20)	Polyurea (5, $0.20)	Polyurea (4-5, $0.25-$0.20)	Epoxy (7-9, $0.14-$0.11)
		Epoxy (3-4, $0.31-$0.24)		Epoxy (3-4, $0.31-$0.24)	

Recommendations shown are:

Material Type (expected service life, equivalent uniform annual cost per foot for a 4-inch-wide marking)

Costs are based on 2013-2014 average unit prices and a 3% discount rate.

Notes:

1 Pavement marking service life is capped at the pavement service life (5 years).

2 Costs shown are for placing materials in existing grooves. Do not install new grooves for maintenance striping on HMA.

Table 3. Pavement marking material recommendations for maintenance striping on PCC.

MAINTENANCE STRIPING ON PCC					
Zone	AADT	Pavement Service Life ≤ 10 years		Pavement Service Life > 10 years	
		Surface	Recessed [1]	Surface	Recessed [2]
Northern IL	Low (≤ 7000)	Urethane (2-3, $0.27-$0.18) epoxy (3-4, $0.31-$0.24)	Urethane (5-6, $0.11-$0.10) Epoxy (7-9, $0.14-$0.11)	Urethane (2-3, $0.27-$0.18) Epoxy (3-4, $0.31-$0.24)	Urethane (5-6, $0.11-$0.10, $0.27-$0.23) Epoxy (7-9, $0.14-$0.11, $0.26-$0.21)
	High (> 7000)	Urethane (2-3, $0.27-$0.18) Epoxy (3-4, $0.31-$0.24) Polyurea (3-4, $0.33-$0.25)	Urethane (5-6, $0.11-$0.10) Epoxy (7-9, $0.14-$0.11) Polyurea (7-9, $0.15-$0.12)	Urethane (2-3, $0.27-$0.18) Epoxy (3-4, $0.31-$0.24) Polyurea (3-4, $0.33-$0.25)	Urethane (5-6, $0.11-$0.10, $0.27-$0.23) Epoxy (7-9, $0.14-$0.11, $0.26-$0.21) Polyurea (7-9, $0.15-$0.12, $0.26-$0.21)
Central IL	Low (≤ 7000)	Urethane (3-4, $0.18-$0.14) Epoxy (4-5, $0.24-$0.19)	Urethane (6-7, $0.10-$0.08) Epoxy (8-10, $0.13-$0.10)	Urethane (3-4, $0.18-$0.14) Epoxy (4-5, $0.24-$0.19)	Urethane (6-7, $0.10-$0.08, $0.23-$0.20) Epoxy (8-10, $0.13-$0.10, $0.23-$0.19)
	High (> 7000)	Urethane (3-4, $0.18-$0.14) Epoxy (4-5, $0.24-$0.19) Polyurea (3-4, $0.33-$0.25)	Urethane (6-7, $0.10-$0.08) Epoxy (8-10, $0.13-$0.10) Polyurea (7-9, $0.15-$0.12)	Urethane (3-4, $0.18-$0.14) Epoxy (4-5, $0.24-$0.19) Polyurea (3-4, $0.33-$0.25)	Urethane (6-7, $0.10-$0.08, $0.23-$0.20) Epoxy (8-10, $0.13-$0.10, $0.23-$0.19) Polyurea (7-9, $0.15-$0.12, $0.26-$0.21)
Southern IL	Low (≤ 7000)	Urethane (4-5, $0.14-$0.11) Epoxy (4-5, $0.24-$0.19)	Urethane (6-8, $0.10-$0.07) Epoxy (8-10, $0.13-$0.10)	Urethane (4-5, $0.14-$0.11) Epoxy (4-5, $0.24-$0.19)	Urethane (6-8, $0.10-$0.07, $0.23-$0.18) Epoxy (8-10, $0.13-$0.10, $0.23-$0.19)
	High (> 7000)	Urethane (4-5, $0.14-$0.11) Epoxy (4-5, $0.24-$0.19) Polyurea (4-5, $0.25-$0.20)	Urethane (6-8, $0.10-$0.07) Epoxy (8-10, $0.13-$0.10) Polyurea (8-10, $0.13-$0.11)	Urethane (4-5, $0.14-$0.11) Epoxy (4-5, $0.24-$0.19) Polyurea (4-5, $0.25-$0.20)	Urethane (6-8, $0.10-$0.07, $0.23-$0.18) Epoxy (8-10, $0.13-$0.10, $0.23-$0.19) Polyurea (8-10, $0.13-$0.11, $0.23-$0.19)

Recommendations shown are:

Material Type (expected service life, equivalent uniform annual cost per foot for a 4-inch-wide marking)

Costs are based on 2013-2014 average unit prices and a 3% discount rate.

Notes:

1 Costs shown are for placing materials in existing grooves.
Do not install new grooves for maintenance striping on PCC with less than 10 years remaining service life.

2 First cost shown is for placing materials in existing grooves.
Second cost shown includes the annualized cost of installing new grooves.

Table 4. Pavement marking material recommendations for striping on new HMA.

STRIPING ON NEW HMA			
Zone	AADT	Surface [1]	Recessed [2]
Northern IL	Low (≤ 7000)	Paint (2-2, $0.10-$0.10)	Thermoplastic (6-7, $0.25-$0.22)
		Thermoplastic (3-4, $0.22-$0.17)	Polyurea (7-9, $0.26-$0.21)
	High (> 7000)	Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (6-7, $0.25-$0.22)
		Urethane (2-3, $0.27-$0.18)	Polyurea (7-9, $0.26-$0.21)
		Polyurea (3-4, $0.33-$0.25)	Urethane (5-6, $0.27-$0.23)
		Epoxy (2-3, $0.47-$0.31)	Epoxy (6-8, $0.30-$0.23)
		Preformed Plastic, Type B (3-4, $0.97-$0.74)	Preformed Plastic, Type B (7-9, $0.56-$0.44)
Central IL	Low (≤ 7000)	Paint (2-2, $0.10-$0.10)	Thermoplastic (6-8, $0.25-$0.19)
		Thermoplastic (4-5, $0.17-$0.14)	Polyurea (7-9, $0.26-$0.21)
	High (> 7000)	Thermoplastic (3-4, $0.22-$0.17)	Thermoplastic (6-7, $0.25-$0.22)
		Urethane (2-3, $0.27-$0.18)	Polyurea (7-9, $0.26-$0.21)
		Epoxy (3-4, $0.31-$0.24)	Epoxy (7-9, $0.26-$0.21)
		Polyurea (3-4, $0.33-$0.25)	Urethane (5-6, $0.27-$0.23)
		Preformed Plastic, Type B (4-5, $0.74-$0.60)	Preformed Plastic, Type B (8-10, $0.49-$0.41)
Southern IL	Low (≤ 7000)	Thermoplastic (5-6, $0.14-$0.12)	Thermoplastic (7-9, $0.22-$0.17)
		Urethane (3-4, $0.18-$0.14)	Epoxy (7-9, $0.26-$0.21)
	High (> 7000)	Thermoplastic (4-5, $0.17-$0.14)	Thermoplastic (6-8, $0.25-$0.19)
		Urethane (3-4, $0.18-$0.14)	Epoxy (7-9, $0.26-$0.21)
		Paint (1-2, $0.20-$0.10)	Polyurea (7-9, $0.26-$0.21)
		Polyurea (4-5, $0.25-$0.20)	Urethane (5-6, $0.27-$0.23)
		Epoxy (3-4, $0.31-$0.24)	Preformed Plastic, Type B (8-10, $0.49-$0.41)
		Preformed Plastic, Type B (5-6, $0.60-$0.51)	

Recommendations shown are:

Material Type (expected service life, equivalent uniform annual cost per foot for a 4-inch-wide marking and a 5-inch-wide groove)
Costs are based on 2013-2014 average unit prices and a 3% discount rate.

Notes:
1 Surface applied preformed plastic shall be inlaid application.
2 Recessed preformed plastic shall be standard application.

Table 5. Pavement marking material recommendations for striping on new PCC.

STRIPING ON NEW PCC			
Zone	AADT	Surface	Recessed
Northern IL	Low (≤ 7000)	Urethane (2-3, $0.27-$0.18) Epoxy (3-4, $0.31-$0.24) Polyurea (3-4, $0.33-$0.25) Preformed Plastic, Type B (3-4, $0.97-$0.74)	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21)
	High (> 7000)	No Surface Application!	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21) Urethane (5-6, $0.27-$0.23) Preformed Plastic, Type B (7-9, $0.56-$0.44)
Central IL	Low (≤ 7000)	Epoxy (4-5, $0.24-$0.19) Urethane (2-3, $0.27-$0.18) Polyurea (3-4, $0.33-$0.25) Preformed Plastic, Type B (4-5, $0.74-$0.60)	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21)
	High (> 7000)	No Surface Application!	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21) Urethane (5-6, $0.27-$0.23) Preformed Plastic, Type B (8-10, $0.49-$0.41)
Southern IL	Low (≤ 7000)	Urethane (3-4, $0.18-$0.14) epoxy (4-5, $0.24-$0.19)	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21)
	High (> 7000)	Urethane (3-4, $0.18-$0.14) epoxy (4-5, $0.24-$0.19) Polyurea (4-5, $0.25-$0.20) Preformed Plastic, Type B (5-6, $0.60-$0.51)	Epoxy (7-9, $0.26-$0.21) Polyurea (7-9, $0.26-$0.21) Urethane (5-6, $0.27-$0.23) Preformed Plastic, Type B (8-10, $0.49-$0.41)

Recommendations shown are:

Material Type (expected service life, equivalent uniform annual cost per foot for a 4-inch-wide marking and a 5-inch-wide groove)
Costs are based on 2013-2014 average unit prices and a 3% discount rate.

SECTION 3 INSTALLATION INSPECTION

For markings to reach their expected service lives, they must be installed properly. Major factors that can affect the proper installation of pavement markings are:

- Ambient temperature
- Pavement temperature
- Material temperature
- Pavement surface moisture
- Pavement surface condition (unclean or deteriorated)
- Wind velocity
- Material application rate
- Reflective media application rate

Ambient and pavement temperatures are important because most pavement marking materials require a minimum temperature to achieve proper drying or curing. Material temperature must remain constant so that the material's viscosity remains constant. If the viscosity changes, then the material application rate can be affected and, of greater consequence, the mix ratio of plural component pavement markings (epoxy, polyurea, and modified urethane) will be altered. Pavement surface moisture at the time of application can prevent the marking material from sufficiently bonding with the pavement surface. Wind velocity can affect the application of drop-on reflective media. High winds can cause the reflective media to be poorly dispersed or from reaching the binder material altogether. Material applied too thin will not provide a sufficient substrate for the reflective media to bind to, and beads may sink in material applied too thickly.
The exhibit that accompanies this manual contains installation inspection sheets for materials currently approved for long line pavement markings and an inspection sheet for installing a groove for recessed markings. Criteria listed in these check sheets comply with IDOT Standard Specifications for Road and Bridge Construction.

The following sections describe recommended tests and measurement tools for several of the inspection items.

3.1 Groove Depth Measurement

To assess whether a groove depth is within the allowable range, an inspector will need two plates that are narrower than the groove width and a straight edge that is wider than the groove width. One plate should be the thickness of the minimum allowable groove depth, and the other plate should be the thickness of the maximum allowable depth. The measurement steps are:

1. Place the thinner plate in the groove and lay a straight edge over the plate.
    - If the straight edge rests on the plate and doesn't touch the pavement, then the groove is too shallow.
    - If the straight edge rests on both the plate and the pavement, or on just the pavement, then the groove depth meets the minimum allowable depth.

2. Place the thicker plate in the groove and lay a straight edge over the plate.
    - If the straight edge rests on the pavement and there is a gap between the plate and the straight edge, then the groove is too deep.
    - If the straight edge rests on the plate and the pavement, or on just the plate, then the groove depth does not exceed the maximum allowable depth.

Grooves for preformed plastic are to be cut with gang-stacked diamond saw blades. Ridges within the groove are not to exceed 15 mils in height. Ridge heights may be measured with a contour gauge. If ridge heights exceed 15 mils, then the saw blades may need to be replaced.

3.2 Pavement Surface Cleaning

The surface wetting test is a method for determining whether the pavement surface has been sufficiently cleaned to place pavement markings. Using an eye dropper, place a drop of clean drinking water on the pavement surface. If the drop forms a bead, the surface may need to be re-cleaned. If the drop spreads (wets), the surface is ready to accept application of marking.

3.3 Pavement Surface Moisture

The surface moisture test is a method for determining whether the pavement is dry enough to accept application of marking material. The test steps are:

1. Place a 12" x 12" piece of plastic wrap on the pavement surface and tape the edges.
2. Leave the plastic wrap in place for approximately 15 minutes.
3. After 15 minutes, check for moisture bubbles on the inside surface of the plastic.
4. If moisture bubbles are larger than a pencil eraser, then the pavement has too much water.

3.4 Material Thickness

Markings with a required wet film thickness of 80 mils or less should be measured with a wet film thickness gauge. Figure 2 is an example of a wet film thickness gauge. To measure wet film thickness, press the edge of the gauge vertically into the wet material. Withdraw the gauge and note the deepest tooth with material on it and the next higher tooth that is not coated with material. The wet film thickness lies between these two readings. For materials thicker than 80 mils, place a metal plate or duct tape down in advance of the striping operation. Collect the sample after striping, and when the material has cooled, remove pieces of the sample and measure the thickness with a needle-point micrometer.

Figure 2. Wet film thickness gauge.

3.5 Glass Bead Application Rate

Most glass bead application rates are given in pounds of beads per gallon of the specified marking material. To ensure that beads are applied at the specified rate, the bead guns must be calibrated prior to marking installation. Verifying that the calibration is performed is an inspector's best opportunity to ensure that rates will be met. To calibrate bead guns, the desired travel speed must first be known. Then, while the striping truck is stationary, beads are sprayed into a container for a pre-determined amount of time, usually a few seconds. Figure 3 is a photo of this step.

Figure 3. Glass bead calibration.

The beads are then poured into a graduated cylinder, and the volume of beads is read. The volume of beads should correspond with the required application rate for a given travel speed. For example, to place 10 pounds of Type I glass beads per gallon of material while traveling 4 miles per hour, the volume of beads collected during a 15-second spray should be 1,200 milliliters. If the volume is too low, then the bead flow needs to be increased. If the volume is too high, then the bead flow needs to be decreased. Table 6 is a bead gun calibration chart for a 10-second spray of Type I beads being placed on a 6-inch-wide marking with a 15-mil wet film thickness. Bead calibration charts for other bead types and other marking material widths and thicknesses may be acquired from material manufacturers.

Table 6. Volume (milliliters) of Type I glass beads using a 10-second spray for a 6-inch-wide marking with a 15-mil wet film thickness

Travel Speed (MPH)	Bead Application Rates			
	6 lbs/gal	8 lbs/gal	10 lbs/gal	12 lbs/gal
8	960	1280	1600	1920
7	840	1120	1400	1680
6	720	960	1200	1440
5	600	800	1000	1200
4	480	640	800	960
3	360	480	600	720
2	240	320	400	480

3.6 Glass Bead Dispersion/Retroreflectivity

At the time of this manual's publication, IDOT specifications did not require a minimum retroreflectivity, but markings are required to be retroreflective. Therefore, the "Sun Over Shoulder" test, from Texas DOT Test Method Tex-828-B, can be used to assess retroreflective properties. The test steps are:

1. When the sun is between 20 and 80 degrees above the horizon, position yourself so that the sun is behind you.
2. View the stripe in front of you along a plane parallel to your shadow.
3. Adjust your distance from the stripe to where the shadow of your head touches the stripe area being observed.
4. From this position, evaluate bead dispersion and retroreflective qualities of the stripe.

Figure 4 shows a demonstration of this test method.

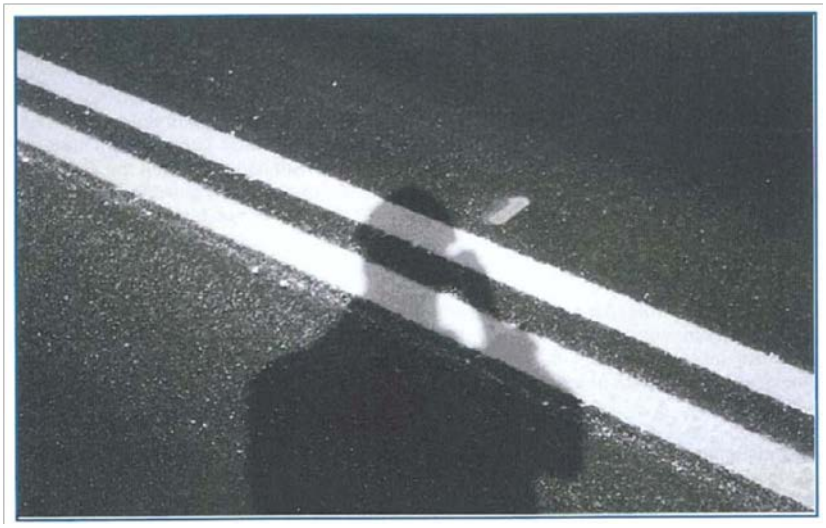

Figure 4. Demonstration of sun over shoulder test method.

Glass beads will provide optimum retroreflectivity if they are properly embedded in the liquid marking material. To achieve optimum retroreflectivity, 50% to 60% of the bead diameter should be below the surface of the marking material. A magnifying lens can be used to examine the depth of bead embedment.

Exhibit

Installation Inspection Sheets

Grooving for Recessed Markings

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge	Lane Line: 1 2 3 R Edge
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. TEST SECTION

1. Groove Depth

Minimum Allowable Groove Depth (mils) =		Maximum Allowable Groove Depth (mils) =	

At the start of grooving operations, Contractor shall install a 50 ft test section.
Groove depth measurements shall be taken at 10 ft intervals within the test section.
All groove depth measurements shall be within allowable range.

	Groove Depth Measurements					
	#1	#2	#3	#4	#5	
Is measurement within allowable range? (yes/no)						

Are all 5 measurements within the allowable range? (yes/no)	

2. Surface Texture

A. For Preformed Plastic Pavement Marking Installations

Is groove surface smooth, and are any ridges less than 16 mils in height? (yes/no)	

B. For Liquid Pavement Marking Installations

Does groove have a regular textured surface? (yes/no)	

3. Groove Width

Is groove width one inch wider than the specified pavement marking line? (yes/no)	

II. GROOVE INSTALLATION

1. Distance from Longitudinal Joint of Edge

Required Distance:	≥ 4"	Measured Distance =	

2. Depth Consistency

Was cutting head operated at the appropriate speed in order to prevent undulation of the cutting head and grooving at an inconsistent depth? (yes/no)	

III. NOTES

Preformed Plastic - Inlaid Application

Contract No:		**Location**			
Pay Item No:		Route			
Date:		Beg MP/Sta:		End MP/Sta:	
Inspector:		**Lines (Circle All That Apply)**			
Site Notes:		L Edge	Lane Line: 1 2 3		R Edge
		Note: Lane lines are counted left to right from the direction of travel			
		Symbols Present?	Yes	No	

I. SURFACE PREPARATION			
1. Surface Cleaning			
Is surface free of dirt and debris? (yes/no)			
2. Surface Moisture			
Has it rained in the past 24 hours? (yes/no)			
Is the pavement surface dry? (yes/no)			
3. Pavement Temperature			
Required Temp:	150°F ± 5°F	Measured Temp =	
II. PAVEMENT MARKING APPLICATION			
1. Ambient Temperature			
Measured Temp =			
2. Tamping			
Was tape tamped with a 200lb load? (yes/no)			
* Note: Approximately 2/3 of the thickness of the tape should be embedded in the HMA.			
3. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
4. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
III. NOTES			

Preformed Plastic - Standard Application

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge	Lane Line: 1 2 3 R Edge
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION

1. Surface Age

What is the pavement's surface age?	

Notes:	All standard applied preformed plastic shall be recessed.
	New PCC Pavement: Surface cleaning (and marking placement) shall not begin until 30 days or more of curing.
	New HMA & Seal Coat Surfaces: Surface cleaning (and marking placement) shall not begin until 2 weeks after placement of pavement surface.

2. Surface Cleaning

Was surface cleaned to remove dirt, grease, and debris? (yes/no)	
New Textured Surface PCC: Has all visible evidence of curing compounds on peaks and valleys been removed? (yes/no)	

3. Surface Moisture

Has it rained in the past 24 hours? (yes/no)	
Is the pavement surface dry? (yes/no)	

4. Pavement Temperature

Required Temp:	≥ 70°F	Measured Temp =	

II. PAVEMENT MARKING APPLICATION

1. Ambient Temperature

Required Temp:	≥ 60°F	Measured Temp =	

2. Primer Sealer

Is a primer sealer required? (yes/no)		If yes, was it placed? (yes/no)	

3. Tamping

Was tape tamped with a 200lb load? (yes/no)	

4. Distance from Longitudinal Joint or Pavement Edge

Required Distance:	≥ 2"	Measured Distance =	

5. Lateral Deviation

Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)	

Paint

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge	Lane Line: 1 2 3 R Edge
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION

1. Surface Cleaning	
Was surface cleaned to remove dirt, grease, and debris? (yes/no)	
2. Surface Moisture	
Has it rained in the past 24 hours? (yes/no)	
Is the pavement surface dry? (yes/no)	

II. PAVEMENT MARKING APPLICATION

1. Ambient Temperature			
Required Temp:	≥ 50°F	Measured Temp =	
2. Wet Film Thickness			
Required Thickness:	≥ 16 mils	Measured Thickness =	
3. Glass Bead Application Rate			
Required Rate =	6.0 lb/gal	Measured Rate =	
4. Bead Dispersion / Retroreflectivity			
Are beads well dispersed? (yes/no)			
Is marking retroreflective? (yes/no)			
5. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
6. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
7. Marking Width			
Required Width =	Specified Width ± 1/4"	Measured Width =	

III. NOTES

Thermoplastic

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge	Lane Line: 1 2 3 R Edge
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION

1. Surface Cleaning			
Was surface cleaned to remove dirt, grease, and debris? (yes/no)			
2. Surface Moisture			
Has it rained in the past 24 hours? (yes/no)			
Is the pavement surface dry? (yes/no)			
3. Pavement Temperature			
Required Temp:	≥ 55°F	Measured Temp =	

II. PAVEMENT MARKING APPLICATION

1. Resin Temperature			
Required Temp =	400 - 475°F	Measured Temp =	
2. Applied Material Thickness			
Required Thickness =	100 - 110 mils	Measured Thickness =	
3. Glass Bead Application Rate			
Required Rate =		Measured Rate =	
4. Bead Dispersion / Retroreflectivity			
Are beads well dispersed? (yes/no)			
Is marking retroreflective? (yes/no)			
5. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
6. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
7. Marking Width			
Required Width =	Specified Width ± 1/4"	Measured Width =	

III. NOTES

Epoxy

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge | Lane Line: 1 2 3 | R Edge	
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION

1. Surface Cleaning			
New PCC Pavement:	Was surface air-blasted clean to remove all curing compounds and latents? (yes/no)		
All Other Pavements:	Was surface cleaned to remove dirt, grease, and debris? (yes/no)		
2. Surface Moisture			
Has it rained in the past 24 hours? (yes/no)		Is the pavement surface dry? (yes/no)	
3. Pavement Temperature			
Required Temp:	≥ 35°F	Measured Temp =	

II. PAVEMENT MARKING APPLICATION

1. Ambient Temperature			
Required Temp:	≥ 35°F	Measured Temp =	
2. Material Temperatures			
Temp Prior to Mixing =		Temp at Gun Tip =	
3. Wet Film Thickness			
Required Thickness =	20 mils ± 1 mil	Measured Thickness =	
4. Small Glass Bead Application Rate			
Required Rate =	10 lb/gal	Measured Rate =	
5. Large Glass Bead Application Rate			
Required Rate =	10 lb/gal	Measured Rate =	
6. Bead Dispersion / Retroreflectivity			
Are beads well dispersed? (yes/no)		Is marking retroreflective? (yes/no)	
7. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
8. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
9. Marking Width			
Required Width =	Specified Width ± 1/4"	Measured Width =	

Modified Urethane

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge | Lane Line: 1 2 3 | R Edge	
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION			
1. Surface Cleaning			
New PCC Pavement:	Was surface air-blasted clean to remove all curing compounds and latents? (yes/no)		
All Other Pavements:	Was surface cleaned to remove dirt, grease, and debris? (yes/no)		
2. Surface Moisture			
Has it rained in the past 24 hours? (yes/no)		Is the pavement surface dry? (yes/no)	
3. Pavement Temperature			
Required Temp:	≥ 35°F	Measured Temp =	
II. PAVEMENT MARKING APPLICATION			
1. Ambient Temperature			
Required Temp:	≥ 35°F	Measured Temp =	
2. Material Temperatures			
Temp Prior to Mixing =		Temp at Gun Tip =	
3. Wet Film Thickness			
Required Thickness =	20 mils ± 1 mil	Measured Thickness =	
4. Small Glass Bead Application Rate			
Required Rate = (Manufacturer's Rate)		Measured Rate =	
5. Large Glass Bead Application Rate			
Required Rate = (Manufacturer's Rate)		Measured Rate =	
6. Bead Dispersion / Retroreflectivity			
Are beads well dispersed? (yes/no)		Is marking retroreflective? (yes/no)	
7. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
8. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
9. Marking Width			
Required Width =	Specified Width ± 1/4"	Measured Width =	

Polyurea

Contract No:		**Location**	
Pay Item No:		Route	
Date:		Beg MP/Sta:	End MP/Sta:
Inspector:		**Lines (Circle All That Apply)**	
Site Notes:		L Edge	Lane Line: 1 2 3 R Edge
		Note: Lane lines are counted left to right from the direction of travel	
		Symbols Present?	Yes No

I. SURFACE PREPARATION			
1. Surface Cleaning			
New PCC Pavement:	Was surface air-blasted clean to remove all curing compounds and latents? (yes/no)		
All Other Pavements:	Was surface cleaned to remove dirt, grease, and debris? (yes/no)		
2. Surface Moisture			
Has it rained in the past 24 hours? (yes/no)		Is the pavement surface dry? (yes/no)	
3. Pavement Temperature			
Required Temp:	≥ 40°F	Measured Temp =	
II. PAVEMENT MARKING APPLICATION			
1. Ambient Temperature			
Required Temp:	≥ 40°F	Measured Temp =	
2. Material Temperatures			
Temp Prior to Mixing =		Temp at Gun Tip =	
3. Wet Film Thickness			
Required for new HMA: Required for other pavements:	≥ 20 mils ≥ 15 mils	Measured Thickness =	
4. Small Glass Bead Application Rate			
Required Rate = (Manufacturer's Rate)		Measured Rate =	
5. Large Glass Bead Application Rate			
Required Rate = (Manufacturer's Rate)		Measured Rate =	
6. Bead Dispersion / Retroreflectivity			
Are beads well dispersed? (yes/no)		Is marking retroreflective? (yes/no)	
7. Distance from Longitudinal Joint or Pavement Edge			
Required Distance:	≥ 2"	Measured Distance =	
8. Lateral Deviation			
Does the lateral deviation of any 10 ft section exceed 1 inch? (yes/no)			
9. Marking Width			
Required Width =	Specified Width ± 1/4"	Measured Width =	

SECTION 4 SUPPORTING DOCUMENTS

Documents related to or supporting this manual are the FHWA's Manual on Uniform Traffic Code Devices (MUTCD), IDOT's Standard Specifications for Road and Bridge Construction, and Illinois Center for Transportation (ICT) research project R27-77, "Evaluating Pavement Markings on Portland Cement Concrete and Various Asphalt Surfaces." Copies of these documents can be found at the following links:

MUTCD
http://mutcd.fhwa.dot.gov/

IDOT Standard Specifications for Road and Bridge Construction
http://www.dot.il.gov/desenv/hwyspecs.html

ICT Project R27-77
http://www.ict.illinois.edu