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Chapter Seventy-six

PAVEMENT MARKINGS

76-1.0 GENERAL

Markings must be uniform in design, position and application. As with all other traffic control devices, it is imperative that markings be uniform so that they may be recognized and understood instantly. The proper use of pavement markings will reduce accidents on most facilities. New and improved markings have been demonstrated to significantly reduce nighttime and wet pavement accidents.

This chapter presents the Department's criteria for the application of permanent pavement markings. Chapter Eighty-three presents criteria for the use of temporary pavement markings through construction zones.

76-1.01 MUTCD Context

Throughout the *Manual on Uniform Traffic Control Devices (MUTCD)*, the words "shall", "should," and "may" are used to indicate the appropriate application of traffic control devices. Section 75-1.0 defines the Department's application for these qualifying words, which apply to pavement markings.

76-1.02 Line Types

Figure 76-1A, Types of Pavement Lines, presents typical pavement stripes and their application. Section 76-2.0 provides additional information on the applications of these pavement markings.

76-1.03 References

For additional information on pavement markings, the designer is referred to the following publications.

1. *Manual on Uniform Traffic Control Devices,* FHWA;

2. *Traffic Control Devices Handbook*, FHWA;

3. *Traffic Engineering Handbook*, ITE; and

4. NCHRP Synthesis 138, *Pavement Markings: Materials and Application for Extended Service Life.*

76-1.04 Official Action

Where a new or revised pavement marking alters the regulation of an existing condition, an "official action" is required. For State-controlled highways, the designer must coordinate and obtain an approval for the proposed change from the appropriate district traffic engineer before implementation of the proposed change. For locally controlled facilities, approval must be obtained from the appropriate jurisdiction before implementation. Adding a new no-passing zone or revising the length of an existing no-passing zone will require an "official action." Because pavement markings, in general, supplement signs, an "official action" will only typically be required for changing the sign and will not be required for the changing of the pavement marking.

76-2.0 APPLICATIONS

The following sections provide numerous guidelines for the application of pavement markings. The MUTCD provides additional guidance and illustrations for the placement of pavement markings.

76-2.01 Travel Way Markings

76-2.01(01) Center Lines

All INDOT highways require a center line. Based on the highway type, the following will apply.

1. On 4-lane, undivided rural highways and on city streets where there are a minimum of two lanes of moving traffic in each direction at all times, the center line will consist of two 100-mm wide solid yellow lines, separated by a space of approximately 200 mm.

2. On 2-way, 2-lane highways and streets, the center line should be a yellow broken line; a

double line consisting of a yellow broken line and a solid yellow line; or double solid yellow line. The line type depends upon the allowable passing condition at each specific site.

3. The line marking for the center of a 1-way street or a multi-lane divided highway is a broken white line.

4. Center lines are typically not continued through intersections with public roads but are typically continued across driveways.

5. At signalized intersections, a 15-m long center line should be provided on the minor facility if it has no markings.

Center line markings are typically placed 100 mm on either side of the longitudinal joint of the roadway. This will minimize the need for repainting after a joint-sealing operation.

For non-INDOT highways, center lines are recommended at the following locations.

1. Roadway Widths. In rural areas, center lines should be provided on 2-lane roadways which have a surface width of 4.9 m or more and with prevailing speeds greater than 50 km/h.

2. Divided Highways. Center lines should be provided on all divided highways with four or more lanes.

3. Urban Areas. In residential or business districts, center lines should be provided on all through highways and on other highways where there are significant traffic volumes.

4. Low-Volume Roads. On paved low-volume roads, center lines should be provided where the AADT equals or exceeds 300 vehicles per day.

5. Intersections. Center lines are typically not continued through intersections with public roads but are typically continued across driveways. At signalized intersections, a 15-m long center line should be provided on the minor facility if it has no markings.

6. Horizontal Curves. If not provided elsewhere, center line markings should be provided on horizontal curves with radii of 700 m or less. The markings and delineation should begin about 300 m in advance of the PC, continue through the curve and end about 300 m beyond the PT.

7. Bridges. If not provided elsewhere, center line markings should be provided at narrow bridges where the approaching pavement width is 5.5 m or greater, including paved

shoulders, and where the bridge width is less than the approaching roadway width. The markings and delineation should begin about 300 m in advance of the restricted bridge, continue across the bridge and end about 300 m beyond the bridge.

8. Field Conditions. Center line markings should be provided as necessary to meet field conditions or where engineering studies indicate a need.

76-2.01(02) Lane Lines

Lane lines are used to separate lanes of traffic traveling in the same direction. For non-freeway facilities, the lane line will be a 100-mm wide, broken white, reflectorized line. Lane lines on freeways will be a 125-mm wide, broken white, reflectorized line. A solid white line may be used if lane switching should be discouraged (e.g., approaches to signalized intersections). All lane lines should be offset 100 mm from the longitudinal construction joint to facilitate future maintenance operations. Lane lines are typically not continued through intersections with public roads but are typically continued across driveways.

76-2.01(03) Edge Lines

Edge lines are used on all INDOT highways. For non-INDOT paved highways, the use of edge lines should be considered as follows:

1. along all multi-lane facilities,
2. along roadways having a paved surface width of 6.0 m or greater,
3. across bridges with widths 5.5 m or greater,
4. where run-off the road accidents are disproportionately high, and
5. where engineering judgment indicates a need.

Left-hand edge lines are median lines and are discussed in Section 76-2.01(04). Right-hand edge lines are typically 100-mm wide, solid white, reflectorized lines. The following presents guidelines for the placement of edge lines on INDOT and non-INDOT facilities.

1. Intersections/Driveways. Gaps must be provided at all public road intersections but are generally not provided at driveways.

2. Interchanges. For edge lines at interchanges, see Section 76-2.04.

3. Paved Shoulders/Curb Offsets. Edge lines should be placed approximately 100 mm from

the longitudinal construction joint to eliminate the need for repainting after joint-sealing operations. For roadways with curbs and no curb offset, the curb itself may be painted with reflectorized solid white paint, or a 100-mm, solid white line may be applied to the pavement adjacent to the curb.

4. Unpaved Shoulders. For roadways with unpaved shoulders, the edge line should generally be placed approximately 100 mm from the pavement edge. However, the edge line should be placed 0.3 m from the edge of pavement (see Figure 76-2A, Location of Edge Lines (Unpaved Shoulders)) if one of the conditions exists as follows:

   a. if placing the edge line approximately 100 mm from the pavement edge would result in a lane width greater than 3.6 m; or

   b. the width from the center line to the pavement edge is a minimum of 3.3 m and the road section is without at least a 0.6-m stabilized (compacted aggregate or bituminous) shoulder or a minimum 1.2-m usable earth shoulder.

   If the above criteria results in lane widths greater than 3.9 m, consideration should be given to revising the placement of the center line and edge line so that only a 3.6-m lane is provided.

5. Uniformity. Edge lines should be located to provide a constant lane width, as practical, throughout the roadway section. The widest lane practical, up to 3.6 m, should be provided.

6. Bridges. Edge lines should be continued straight across a structure if the lane widths across the bridge are as wide or wider than the lane widths approaching the bridge. Where the lane width on the structure is less than the approaching lane width, the edge line alignment will need to be tapered to meet the narrower roadway width across the bridge. Section 76-2.01(06) provides the taper lengths. The INDOT *Standard Drawings* provide additional information on the placement of traffic control devices, including edge lines across bridge structures.

76-2.01(04) Median Lines

Median lines are required on all multi-lane divided highways. Gaps are provided at all at-grade intersections and median crossovers. The following presents the median line applications based on the median curb type.

1. No Curbs. Provide a solid yellow, reflectorized median line, 100-mm wide, at the left

edge of the travelway.

2. Curbs Offsets. For facilities with curbs and curb offsets, provide a solid yellow, 100-mm wide, reflectorized median line at the left edge of the travel lane. The median marking should typically be placed a minimum of 100 mm on either side of the longitudinal joint between the roadway and the curb and gutter.

3. No Curb Offset. For facilities with curbs and no curb offsets, the curb itself may be painted with a solid yellow, reflectorized paint, or a 100-mm, solid yellow line may be applied to the pavement adjacent to the curb.

76-2.01(05) Channelizing Lines

Channelizing lines may be a solid white or solid yellow reflectorized line. They may vary in width from 100 mm to 600 mm depending on field conditions and the emphasis required. Yellow channelizing markings are used between opposing traffic. White channelizing markings are used for separating traffic traveling in the same direction. Section 76-2.03 provides information on channelizing lines at intersections. Section 76-2.04 provides information on channelizing lines at interchanges.

Channelizing lines may also be used to indicate a flush median or to emphasize a continuous mounded corrugated median. Channelizing lines are generally not used unless the median is at least 1.2 m or wider.

76-2.01(06) Lane Transitions

Where lane reductions are required, pavement markings are used to guide the motorist through the transition area. Figure 76-2B provides the minimum taper rates and lengths that should be used for lane reductions. Figure 76-2C, Taper Length Criteria (Application), illustrates the application of the various taper types. These transition lengths are also appropriate for the pavement markings.

For downstream tapers (e.g., the beginning taper for left- and right-turn lanes, freeway exits), as defined in the *MUTCD*, the minimum taper should desirably be 30 m. At a minimum, the downstream taper may be 15 m.

Figure 76-2D, Transition Markings (4-Lane Undivided to 2-Lane Undivided), Figure 76-2E, Transition Markings (4-Lane Divided to 2-Lane Undivided - Right), and Figure 76-2F, Transition

Markings (4-Lane Divided to 2-Lane Undivided - Left), illustrate the typical pavement marking patterns used for transitioning from 4 to 2 lanes.

76-2.01(07) Truck-Climbing Lanes

Section 44-2.0 presents the Department's criteria for truck-climbing lane warrants and design. Figure 76-2G illustrates the pavement markings that should be used with truck-climbing lanes.

76-2.02 No-Passing Zones

76-2.02(01) Warrants

The following are the Department's warrants for no-passing zones.

1. Horizontal/Vertical Curves. Where center lines are installed, no-passing zones will be established at vertical and horizontal curves and elsewhere on 2- and 3-lane highways where an engineering study indicates passing must be prohibited because of inadequate sight distances or other special conditions. Figure 76-2H provides the minimum distances that should be used for determining no-passing zone markings. These values provide sufficient distance for the passing vehicle to abort the passing maneuver. These values should not be confused with the minimum passing sight distances presented in Section 42-3.0, which are used for geometric design purposes and are based on the assumption that the passing vehicle will be able to complete the passing maneuver.

2. Roadway Obstacles. Passing should not be allowed prior to or around obstacles which are located next to or within the roadway (e.g., bridge piers). The pattern of the no-passing zone in the immediate vicinity of these obstructions will be reviewed and determined by the district traffic engineer for INDOT highways and the local authority for local roads.

3. Transitions (4 to 2 Lanes). Figure 76-2D, Transition Markings (4-Lane Undivided to 2-Lane Undivided), Figure 76-2E, Transition Markings (4-Lane Divided to 2-Lane Undivided - Right), and Figure 76-2F, Transition Markings (4-Lane Divided to 2-Lane Undivided - Left), illustrate the typical placement of no-passing zone markings in the transition area.

4. Bridges. The following no-passing zone determinations will apply to bridges.

a. For bridge widths that are narrower than the full approach width or for 1-lane bridges, passing will typically not be allowed on the bridge. Figure 76-2 I provides minimum lengths for implementing the no-passing criteria in advance of the structure.

b. For bridge widths which meet the full approach roadway width and for narrow bridges where the full approach lane widths are carried across the bridge, the need for no-passing markings will be determined based on the criteria in Item 1.

5. Intersections/Railroad Crossings. In general, passing is not allowed prior to or through major intersections and railroad crossings. Figure 76-2 I provides the minimum lengths for implementing the no-passing criteria in advance of major intersections and railroad crossings.

6. Gaps. Figure 76-2J provides the minimum distances for passing between successive no-passing zones. If these distances cannot be met, then the no-passing zones should be connected. Note that, if the distance from the end of a preceding zone and the no-passing zone for the intersection is less than the minimum allowable gap in Figure 76-2J, Minimum Passing Zone Gaps, the no-passing line should be continued to the intersection.

7. Traffic Volumes. No-passing zones may be established where opposing traffic volumes are such that it would be impractical or unsafe to allow passing maneuvers (e.g., urban areas). This determination will be decided on a case-by-case basis.

8. Boundaries. A review of the no-passing areas should be conducted a sufficient distance prior to and beyond the marking area to ensure that the area will be properly marked (e.g., eliminating less than minimum gaps).

76-2.02(02) Design Criteria

The following are the Department's design criteria for determining no-passing zones.

1. Design Speed. If known, the highest of the posted speed, the 85th percentile speed or the design speed should be used to establish the no-passing zone. If the posted speed limit is used, the speed used in determining the distances in Figures 76-2H and 76-2 I should be approximately 10 km/h higher than the posted speed. For example, if the posted speed limit is 90 km/h, use the appropriate sight distance for 100 km/h.

2. Passing Distances. Figures 76-2H and 76-2 I present the various distances used to mark no-passing zones. The beginning of a no-passing zone is that point at which the distance

first becomes less than that specified in Figures 76-2H and 76-2 I. The end of the zone is that point at which the distance again becomes greater than the minimum specified in Figures 76-2H and 76-2 I.

3. Minimum Length. The minimum length for a no-passing zone is 150 m. If the no-passing zone, as determined above, is less than 150 m, additional no-passing markings must be added to the beginning of the no-passing zone until the 150-m minimum criteria is met.

4. Eye/Object Heights. For determining no-passing zones, the distance is measured from a 1070-mm height of eye to a 1070-mm height of object.

76-2.02(03) Pavement Markings

No-passing zone lines are solid yellow, reflectorized lines which are 100-mm wide. These lines are separated from a solid or broken yellow center line with a 200-mm gap.

Section 75-3.07 provides Department practices for supplementing no-passing lines with no-passing signs and delineators.

76-2.02(04) No-Passing Zone Record

A no-passing zone record is required for "official action" purposes on INDOT roadways and is recommended for non-INDOT roads. This also assists in the remarking of no-passing zones due to worn out markings or after resurfacing. Developing the record involves taking field measurements and recording the location of the beginning and ending points of all no-passing lines. In developing the written no-passing zone record, the following should be noted for INDOT highways.

1. Beginning/Ending Points. The record should begin and end at all county lines or at the extreme point of the road within the county. For even-numbered roads, the record should begin at the west county line or at the westerly beginning point of the road within the county. The record should proceed easterly and terminate at the east county line or at the easterly termination point of the road within the county. For odd-numbered roads, the record should begin at the south county line or at the southerly beginning point of the road within the county. The record should proceed northerly and terminate at the north county line or at the northerly termination point of the road within the county.

2. Measurements. The beginning reading is at zero and measurements will be read in meters. The measuring device should be calibrated to measure within 2 m per km. For survey routes greater than 15 km, the record should be stopped at an intersection and reset to zero to eliminate any accumulated errors resulting from distance measuring. All the elements noted in Item 3 should be referenced in meters from the beginning of the record.

3. Recorded Items. The Recorder should note the following elements in the no-passing zone record.

   a. The center line of all intersecting city streets, county roads and State highways should be measured and recorded. The name and/or number of the street or road should also be recorded. The names and/or numbers for those facilities which are not signed in the field should be obtained from the local official agency maps or records. Federal-aid route numbers should not be used.

   b. The Recorder should locate and identify all permanent-type landmarks, including railroad crossings, narrow and 1-lane bridges (over 6.0 m in length), obstructions, and city or town limits (by sign designating such limits).

   c. All major bridges not included above should be noted in the record under the "special reference" notation. This will allow the name of the stream or river to be identified in the record.

   d. All reference markers from the roadway reference system should be noted.

Records for non-INDOT facilities may be prepared similarly to INDOT highways.

76-2.03 Intersection Markings

Figure 76-2K provides an example of several of the markings used at intersections. The following sections provide additional information on the various intersection pavement markings.

76-2.03(01) Stop Lines

For State facilities, the stop line will be a solid white, reflectorized line, 600-mm wide. Stop lines shall extend across all approach lanes, usually to the center line. They should be placed 1.2

m in advance of the nearest crosswalk line and generally perpendicular to the center line. The stop line will typically be parallel with the crosswalk. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point and, generally, perpendicular to the line of travel. The stop line should not be placed more than 9 m or less than 1.2 m from the nearest edge of the crossing travel lane or point of potential conflict (e.g., cross walk, turn lane, turning vehicle path).

Under some circumstances, the location of the stop line should be adjusted to fit field conditions. For example, where turning trucks are known to encroach into the opposing lane, the stop line should be placed beyond the point of potential conflict. On multi-lane facilities that intersect the cross road at an angle, it may be appropriate to stagger the stop line for each lane. This may be especially important at signalized intersections where clearance times may be substantial.

76-2.03(02) Crosswalks

Crosswalk lines must be solid white, reflectorized lines not less than 150-mm wide. They are used to mark both edges of the crosswalk. The distance between lines is usually determined by the width of the sidewalks to be connected; however, they should not be spaced less than 1.8-m apart. The crosswalk must encompass all curb ramps. For information on curb ramps and the crosswalk width, see Section 51-1.08. The *MUTCD* provides additional information on various other crosswalk types.

76-2.03(03) Channelized Islands

Figure 76-2L illustrates the typical pavement markings used to delineate a raised, corrugated, triangular island. Figure 76-2M illustrates the typical pavement markings used to delineate a raised corrugated and a painted, flush elongated island.

76-2.03(04) Multiple Turn Lanes

For multiple turn lanes (e.g., dual left-turn lanes), a series of single dotted lines may be used to guide the turning traffic through the intersection considering the turning path of the design vehicle(s). These lines are the extension of the lane lines and, therefore, are the same color as the lane line.

76-2.03(05) Word/Symbol Markings

Word and symbol markings on the pavement may be used to guide, warn or regulate traffic. They should be limited to not more than a total of three lines of information, and they must be white in color. For additional information on the design and layout of word and symbol markings, see the INDOT *Standard Drawings* or the FHWA *Standard Alphabets for Highway Signs and Pavement Markings*, which are used in conjunction with the *MUTCD*.

Symbol arrows may be used to convey either guidance or mandatory messages; however, where a movement that would otherwise be legal is prohibited, the arrow marking must be accompanied by the pavement-marking word "Only." Signs should be considered in addition to the markings where determined necessary by a field investigation. Signs or markings may be repeated in advance of mandatory turn lanes when necessary to prevent entrapment and to help motorists select the appropriate lane before reaching the end of the line of waiting vehicles.

Pavement-marking words are normally 2.4-m high, except where traffic speeds are very low. If the message consists of more than one word, it should be read "up" (i.e., the first word should be nearest to the approaching driver). At intersections, special markings are normally placed approximately 6 m from the point where traffic stops. The space between words of a single message is suggested to be approximately four times the height of the characters for low-speed roads and up to ten times the height of the characters for high-speed roads. Typical layouts are shown in Figure 76-2N, Traffic Control Word/Symbol Markings.

76-2.04 Interchange Markings

The following presents the Department's practice for installing pavement markings at interchanges:

1. Exit Ramps. Figures 76-2 O and 76-2P present the typical pavement markings used for a parallel and taper exit ramp, respectively.

2. Entrance Ramps. Figures 76-2Q and 76-2R present the typical pavement markings used for a parallel and taper entrance ramp, respectively.

3. Gore Markings. Figure 76-2S illustrates the supplemental gore markings that are used at interchanges. It should be noted that, for all Interstates and other facilities with posted speeds greater than 70 km/h, the gore markings should use the 600-mm striping at 12-m spacings. For facilities with design speeds of 70 km/h or lower, a 300-mm gore striping is used at 6-m spacings.

4. Ramp/Cross Road Junction. Figure 76-2T illustrates the placement of supplemental exit ramp markings that may be used on ramps where wrong-way movements may occur. The design of these markings should conform to the INDOT *Standard Drawings* or the FHWA *Standard Alphabets for Highway Signs and Pavement Markings*.

76-2.05 Miscellaneous Markings

76-2.05(01) Railroad Crossings

In rural areas, the minimum distance from the railroad crossing marking to the stop line should be the stopping sight distance. In urban areas, this distance will vary depending on the signal location and block spacing. Desirably, the minimum distance should be the same as for a rural area. However, this distance is often not practical due to the need to maintain the markings within the same block or between the nearest track and the adjacent traffic signal. Typically, this spacing should not be less than 15 m. The INDOT *Standard Drawings* provide additional details for the location of railroad crossing symbols.

On multi-lane highways, the transverse lines should be extended across all approach lanes, and the individual railroad crossing symbols provided in each lane.

For 2-way left-turn lanes, the center lane should be discontinued across the railroad crossing and marked as a flush median or as a 1-way left-turn lane.

76-2.05(02) Two-Way Left-Turn Lanes (TWLTL)

A TWLTL is a center lane reserved for the exclusive use of left-turning vehicles in either direction. The center lane is marked to delineate the bi-directional, left-turn movement. Section 46-5.0 provides the design details for a TWLTL. Figure 76-2U illustrates the typical marking pattern for a TWLTL. The pavement word and symbol marking groups should, at a minimum, be at least 120-m apart. In rural areas, these marking groups should desirably not exceed 400 m. At signalized or other major intersections, the TWLTL will need to be transitioned to an exclusive left-turn lane. Figure 76-2V illustrates the pavement markings used for this transition. See Section 75-3.05 for information on the appropriate signing for use in conjunction with a TWLTL.

76-2.05(03) School Crossings

Pavement markings for school crossings should only be used with the appropriate signing (i.e., they should not be used without the signing). The need for school crossing signing and markings will be determined on a case-by-case basis in conjunction with the local officials. INDOT's practice is to replace the school crossing markings if they are removed or covered during a project (e.g., resurfacing projects). The INDOT *Standard Dr*awings and the *MUTCD* provide additional guidance for the placement of school crossing markings.

76-2.05(04) Bicycle Facilities

The color and type of lines used for bicycle facilities will be the same color and type as determined for automobiles (e.g., yellow broken line for 2-way bike paths). Broken lines for bicycle paths should have a 1 to 3 ratio (e.g., 1-m line with a 3-m gap). A solid white line should be used to separate pedestrians and bicycles if they share a common facility. The preferential lane symbol as defined in the *MUTCD* must be provided where bicycles and motor vehicles share the same facility and a separate bike lane is provided. Figure 76-2W, Bicycle Markings (Intersections), illustrates the AASHTO *Guide for the Development of Bicycle Facilities* recommendations on how to mark an intersection with vehicles turning right across bike lanes. The *MUTCD* and the AASHTO *Guide* provide additional guidance for marking bicycle facilities.

76-2.05(05) Parking Markings

In general, on-street parking markings will be determined by local criteria. If local criteria are unavailable, the designer should reference the *MUTCD* for details. Section 51-4.0 provides information on the design and layout of parking stalls for off-street parking. Solid white lines, 100-mm to 150-mm wide, are typically used for marking parking stalls. Section 51-1.0 provides the criteria for laying out handicapped parking stalls. The pavement markings will typically be white and/or blue.

76-3.0 PAVEMENT MARKING MATERIALS

76-3.01 Material Types

INDOT is presently using several types of pavement marking materials. Recommended locations for each pavement marking types are presented in Section 76-3.02. All pavement

marking materials must meet the criteria set forth in the Indiana *Standard Specifications*. The pavement marking materials used by INDOT are described below.

1. Paint. Quick-drying paints are typically applied as a 100-mm or wider white or yellow stripe Glass beads are dropped onto the wet paint which then bond to the paint surface when it dries. The use of glass beads greatly enhances the reflectivity of the paint stripe. Per unit cost, paint-applied markings are significantly cheaper than any other method. One of the major disadvantages of paint is that it can be quickly worn away on high-volume roadways and, therefore, often needs to be reapplied more than once a year.

2. Thermoplastic. Thermoplastic markings are typically made from hydrocarbon or alkyd resins, pigment and filler. The materials are heated to high temperatures and are applied in thicknesses of 2.4 mm to 4.8 mm. The material is applied to the surface and, while it is still hot, glass beads are dropped onto the mixture. When the material cools, the glass beads are then bonded to the surface. Thermoplastic markings must be applied to clean, dry bituminous pavements. A primer may be required to ensure satisfactory performance. Thermoplastic markings are significantly more expensive than paint, but often can last 5 or more years when applied properly. Thermoplastic is the preferred marking for high-volume roadways due to its long life.

3. Epoxy Paint. Epoxy markings typically are made from a two-component epoxy resin, pigment, extenders and fillers. The two epoxy resin components are mixed together just prior to being applied to the roadway surface. The two epoxy components produce a chemical reaction which binds them together. Materials using this type of chemical reaction are called thermoset materials. Epoxy markings typically are applied in thicknesses of 0.3 mm to 0.5 mm and can be applied even to wet pavements. Glass beads are typically dropped onto the mixture; however, they may be applied by several different means depending on the epoxy material types used.

4. Preformed Plastic. Preformed plastic markings are typically premade in a factory from vinyl, pigment and fillers and can come in strips, words or symbols. Glass beads are commonly embedded into the surface of the markings at the factory. Application of the marking typically involves removing a protective strip, laying the marking in place and applying pressure with a roller. Temporary tapes are commonly used in construction zones because the tapes can be easily removed. However, a common problem with some temporary preformed plastics is that they tend to break up easily and must be routinely checked for adequacy.

5. Raised Pavement Markers. Raised pavement markers (RPMs) are typically cube-cornered acrylic lenses, tempered-glass lenses, or glass-bead lenses, mounted in either a plastic or iron base. They are commonly placed with an adhesive to either the pavement surface or into a precut groove. For temporary applications, they may be placed in a

plastic base and applied directly to the pavement with an adhesive. RPMs are designed to reflect the striping colors (e.g., white, yellow, red) and are used as a supplement to other markings and as position guidance devices. To enhance the service life, recessed markers are designed to allow a snow plow to pass over the marker.

6. Experimental Markings. With the continued advancement of technology in pavement markings, there will always be new materials or methods available in the placement of pavement markings. The designer is encouraged to pursue the use of these new materials or procedures. However, the use of any experimental pavement marking material on State-maintained facilities must be first approved by the Operations Support Division.

76-3.02 Applications

Figure 76-3A provides the recommended applications for the various pavement markings used by the Department. The following sections provide additional guidance on the application of these various pavement marking materials. For the purpose of the following sections, transverse markings include, but are not limited to, crosswalks, railroad crossings, stop lines, pavement words and symbol markings.

76-3.02(01) Paint

Paint should be used at all locations where it can provide good, year-round visibility and where the additional cost of durable pavement markings cannot be justified. In general, paint should be used as follows:

1. on all roads or streets where the average daily traffic is less than 1000 vehicles per lane;

2. where the remaining surface life of the pavement is less than three years, or where the pavement is scheduled for resurfacing within three years; and/or

3. for marking non-mountable islands and raised curbs.

76-3.02(02) Thermoplastic

Hydrocarbon and alkyd thermoplastic markings may be used on bituminous pavement under the following conditions:

1. Travel Way Lines. Thermoplastic markings may be used for center lines and lane lines at locations that are not proposed or scheduled for resurfacing within the next four years. Where used for edge lines, the standard pattern is 7.4 m of line with a 0.3 m break for drainage.

2. Special Markings. Thermoplastic markings may be used for locations that are not proposed or scheduled for resurfacing within the next three years and where the average daily traffic is in excess of 1000 vehicles per lane.

3. Painting Cycles. Thermoplastic markings may be used on any road that normally requires two or more paintings per year, or on roads which are normally painted only once a year and the minimum average daily traffic exceeds 3500 vehicles per lane.

4. Decision Points. Thermoplastic markings may be used where there is a need for a more positive lane identification because of alignment, transitions or channelization.

76-3.02(03) Epoxy Paint

Epoxy markings may be used for center lines, lane lines and edge lines. They are generally not used for special markings or for marking non-mountable islands and raised curbs because of problems that can develop with the intermittent application. Epoxy markings may be used as follows:

1. at locations where the average daily traffic is in excess of 1000 vehicles per lane, and the location is not proposed or scheduled for resurfacing within the next three years; and/or

2. if the location is not proposed or scheduled for resurfacing within the next two years on any road that normally requires two or more paintings per year, or on any road that is normally painted only once a year and the minimum average daily traffic exceeds 3500 vehicles per lane.

76-3.02(04) Preformed Plastic

In general, the criteria for epoxy markings presented in Section 76-3.02(03) is also applicable for permanent applications of preformed plastic markings; however, they should only be used as follows:

1. there is highway illumination;
2. they can be supplemented by RPMs; or
3. they are permitted, by special provisions, on bridge overlay projects.

Temporary preformed plastic markings are commonly used in construction zones. Temporary preformed plastic markings should not be used for permanent applications.

76-3.02(05) Raised Pavement Markers (RPMs)

Snowplowable RPMs provide a supplemental method of delineation and are positive position guidance devices. They should not be used as a replacement for standard pavement markings or conventional roadside delineation. The INDOT *Standard Drawings* provide details on the placement and color locations for RPMs. In addition, the following placement considerations should be reviewed.

1. Location. Site selection should be based primarily on the need for additional alignment delineation specifically in areas of frequently inclement weather (e.g., fog, smoke, rain) and in areas of low roadway illumination. Typical areas that should be considered for placement of RPMs include areas where vehicles are leaving the roadway, areas showing excessive wear of existing pavement markings, areas with excessive skid marks, interchange ramps, etc.

2. Pavement Life. RPMs generally should not be placed at locations that are scheduled for resurfacing or reconstruction within the next four years.

3. Illumination. RPMs may not be required at locations that are illuminated.

4. Traffic Volumes. RPMs should be considered where traffic volumes exceed 2500 ADT for 2-lane roadways and 6000 ADT for 4-lane roadways. On lower volume roads, an engineering investigation should be conducted to determine whether RPM's may be appropriate to supplement the standard traffic control devices.

5. Spacing. The normal spacing for RPMs on tangent sections is 24 m. Spacing for center line RPMs used in conjunction with no-passing zones may be reduced to 12 m. Six RPMs at 12-m spacing (72 m) may be used in advance of and following any delineated no-passing zone. Consideration should be given to connecting two locations or zones of RPMs where the distance between them is less than 900 m. See the INDOT *Standard Drawings* for additional details for spacings at other locations.

6. Special Locations. Typically, RPMs should not be used exclusively for edge lines or gore markings. RPMs may be allowed at pavement transitions, 1-way and narrow bridges, special channelization areas, or in other areas where there is strong justification for installation of these devices.

76-3.02(06) Surface Conditions

In general, most pavement markings can be used with both bituminous and concrete pavements. It should be noted, however, that pavement markings on bituminous surfaces tend to last longer than those on concrete surfaces. Hot applied thermoplastic pavement marking materials should not be placed on concrete surfaces.

76-4.0 OBJECT MARKERS AND DELINEATORS

76-4.01 Object Markers

76-4.01(01) Types

Object markers are used to mark obstructions which are within or adjacent to the roadway. Where deemed necessary, one or more of the following object markers should be used.

1. Type 1. A Type 1 object marker consists of a 450-mm or larger diamond panel with one of the following arrangements:

    a. Reflectors/Yellow Background. This marker consists of 9 yellow, 75-mm diameter reflectors arranged symmetrically on a yellow diamond panel.

    b. Reflectors/Black Background. This marker consists of 9 yellow, 75-mm diameter reflectors arranged symmetrically on a black diamond panel.

    c. Reflectorized Sheeting. This marker is a yellow diamond panel with a reflective sheeting and no reflectors.

2. Type 2. Type 2 object markers can be either a 150-mm x 300-mm reflectorized, yellow rectangle panel or a 150-mm x 300-mm white rectangle panel with three, yellow 75-mm diameter reflectors. Either type can be arranged vertically or horizontally. Type 2 markers may be larger to meet special conditions.

3. Type 3. A Type 3 object marker consists of a 300-mm x 900-mm rectangular panel with alternating black and reflectorized yellow stripes sloping downward at an angle of 45° toward the side of the obstruction on which traffic is to pass. For objects on the right side, the stripes should begin at the upper right side of the panel and slope downward to the lower left side. For objects on the left side of the panel, the stripes should begin at the upper left side and slope downward to the lower right side.

4. End-of-Road Markers. End-of-road markers are similar to the Type 1 markers except that the reflectors and background colors are red instead of yellow. This marker is used at the end of a roadway where there is no alternative vehicular path.

76-4.01(02) Application

The following provides guidelines for the application of object markings.

1. Mounting Height. For marking object markers 2.4 m or less from the roadway, the bottom of the object marker should normally be approximately 1.2 m above the surface of the nearest travel lane. For objects greater than 2.4 m from the roadway, the bottom of the object marker may be 1.2 m above the ground. Adjustments may be made to the mounting height to meet field conditions.

2. Objects in the Roadway. Obstructions within the roadway should be marked with either a Type 1 or a Type 3 object marker. Obstacles with large surfaces (e.g., bridge piers) may be painted with reflectorized paint in a pattern similar to the Type 3 object marker. Appropriate signing may be used instead of the object marker to direct traffic to one or both sides of the obstruction.

3. Objects Adjacent to the Roadway. Type 2 or Type 3 object markers may be used where objects are relatively close to the roadway (e.g., bridge piers, bridge abutments, culvert headwalls, shoulder dropoffs, gores, small islands). The inside edge of the marker should be in line with the inner edge of the obstruction.

76-4.02 Delineators

Delineators are light retro-reflecting devices mounted along the roadside, which are used to guide the motorist, particularly where the alignment might be confusing and at pavement width transitions. Delineators are defined according to the number of reflecting devices on the posts. For example, a type D2 delineator consists of two yellow or white delineators on a post. The

delineator itself can be either a 75-mm diameter reflective element or a rectangle unit that substitutes for two circular units.

76-4.02(01) Application

The following are the guidelines for the application of delineators.

1. Color. The delineator color should match the color of the edge line. For example, if the edge line is white, the delineator will be white. For the left side of divided highways, if used, the delineator must be yellow. Red delineators may be used on the reverse side of any delineator post for motorists who may be traveling the wrong way on one-way roadways (e.g., ramps).

2. Freeways. Single delineators should be provided on the right side of freeways and on at least one side of interchange ramps. Yellow single delineators may also be provided on the left side.

3. Interchanges. Single delineators should be provided along the outside of curves on interchange ramps. Double or vertically elongated delineators should be installed at 30-m intervals along acceleration and deceleration lanes.

4. Detours. Delineators should be provided along temporary roadways (e.g., crossovers, temporary runarounds) to guide the motorist through the construction zone. See the INDOT *Standard Drawings* for additional details.

5. Median Crossovers. For median crossovers, a double yellow delineator should be placed on the left side of the through roadway and on the far side of the crossover.

6. Transitions. Delineators should be used to guide the motorist through lane narrowing transitions and for lane merges. Figure 76-2D, Transition Markings (4-Lane Undivided to 2-Lane Undivided), Figure 76-2F, Transition Markings (4-Lane Divided to 2-Lane Undivided - Left), Figure 76-2G,Truck-Climbing Lane Markings, and the *INDOT Standard Drawings* provide illustrations on where to place delineators within these transition areas. Where continuous delineation is provided on one or both sides of the highway, the delineation should be continued through the transition area and a closer spacing may be warranted.

7. Lighting. Where lighting is provided, the need to use delineators in the area will be determined on a case-by-case basis.

8. Guardrail. Barrier delineators are required on all concrete median barriers, temporary concrete median barriers, concrete railings and metal beam rail.

9. Islands. Delineators may be used to outline raised islands. A solid yellow reflectorized panel should be used where the islands channelize the traffic to the right. Where traffic may pass on either side of the island, a solid white reflectorized panel should be used. Continuous median islands are generally not delineated unless deemed necessary.

10. No-Passing Zones. The end of the no-passing zone is normally indicated on the right side of the roadway with three, horizontally aligned, white delineators.

11. Raised Pavement Markers. Delineators may be removed along roadways where raised pavement markers are used for a substantial distance.

76-4.02(02) Delineator Placement and Spacing

The INDOT *Standard Drawings* provide criteria for the placement of delineators next to roadways with curbs and roadways with no curbs. They also illustrate the placement of delineators next to roadways with narrow bridges. In addition to the INDOT *Standard Drawings*, the designer should consider the following:

1. Height. The top of the delineator should be placed so that the top of the reflecting head is approximately 1.2 m above the surface of the nearest travel lane.

2. Placement. Delineators should be placed at a constant distance from the roadway edge unless guardrail or other obstructions intrude into the space between the pavement edge and the extension of the line of delineators. Typically, delineators should not be placed less than 0.6 m or more than 2.4 m from the outside edge of the shoulder.

3. Spacing. For tangent sections, delineators should normally be spaced between 60 m to 160 m apart. On Interstates, other freeways or other divided facilities, the delineator spacing should be 120 m. Where normal uniform spacing is interrupted by driveways, cross roads, etc., the delineator should be moved to either side provided the distance does not exceed one-quarter of the normal spacing. If this criteria is exceeded, the delineator may be deleted.

   For horizontal curves, the delineator spacing should be adjusted so that several delineators will always be visible to the driver. Figure 76-4A provides the recommended maximum spacing for delineators around horizontal curves. The spacing around curves should not be less than 6 m or greater than 90 m.