CHAPTER 9. POST-MOUNTED DELINEATORS

INTRODUCTION

Daytime delineation of the roadside generally can be accomplished effectively with pavement markings. Night visibility, however, often requires a different approach to provide long-range delineation of the roadway alignment. Another problem is providing visibility during periods of rain or snow when most pavement markings are obscured. Post-mounted delineators (PMDs) of various forms have gained widespread acceptance as a roadway delineation treatment.

This chapter addresses the uses and types of retroreflective PMDs as defined in the *Manual on Uniform Traffic Control* Devices *(MUTCD)*.[1] Object marking is not included here but is addressed in chapter 10.

USES

The purpose of post delineation is to outline the edges of the roadway and to accent critical locations. The use of PMDs as a delineation device has been accepted by the Federal Highway Administration (FHWA), The Institute of Transportation Engineers, and the American Association of State Highway and Transportation Officials. As a result, PMDs are recommended for the entire Interstate System.

The *MUTCD* (section 3D-1) defines these devices as follows: "Road delineators are light-retroreflecting devices mounted at the side of the roadway, in series, to indicate the roadway alignment."

These delineators usually are mounted on posts 4 feet (1.2 meters) above the pavement. Under normal atmospheric conditions, they should be visible at a distance of 1,000 feet (305 meters) when illuminated by the high beams of standard automobile headlights. The retroreflective element should have a minimum dimension of 3 inches (76 millimeters).

The *MUTCD* further states that "delineators shall be provided on the right side of expressway roadways and on at least one side of interchange ramps." They also are recommended for use on certain median crossovers, acceleration or deceleration lanes, and transition situations.

One study reported that drivers react most favorably to delineators on curves of 7 degrees (0.122 radian) or less.[80] For sharper curves, some other form of extra delineation should be used, such as chevron alignment signs.

Between interchanges on well-lit roadways, PMDs are optional. Fixed overhead lighting tends to wash out the retroreflection from PMDs, rendering them ineffective at night.

Large white-faced target plates have been used on PMDs where daylight route guidance is needed. Where post delineation is required in the vicinity of a guardrail, as on a horizontal curve, the pattern should continue uninterrupted through the guardrail section. The PMDs should be placed behind the guardrail. In these cases, the guardrail retroreflectors may be eliminated.

In all cases, the color of PMDs must conform to the color of edgelines stipulated in the *MUTCD* section 3B-6. The *MUTCD* standardizes certain characteristics, such as mounting height, number, spacing, and color of retroreflectors; criteria for retroreflective elements; and required locations. It specifically does not address physical characteristics. The types of posts used and other functional considerations are to be determined by the State or local highway agency. Nonetheless, the *MUTCD* should be consulted to ensure uniformity and consistency in usage.

In actual practice, there appears to be little consistency in the use of PMDs. Requirements, such as height and placement in relation to the shoulder, are standardized. Most inconsistencies are found in the size, shape, and color of the retroreflective unit, spacing between PMDs, and the warrants for installation. Since the *MUTCD* is relatively permissive in these areas, PMD systems vary not only from State to State but between districts and even within districts.

Although PMDs have proven safe, standardization of PMD use is unlikely in this era of tight budgets. Tradeoffs must be made when selecting a delineation technique to get the best value for a certain cost. In this context, the value of long-range delineation and night visibility attained with PMDs should be recognized. This is especially true considering these devices' low ratio of cost-to-service life.

MATERIALS

A PMD usually consists of a retroreflective element, the support or mounting post, and possibly a backplate. A variety of materials is available for each of these components. The basic components and their physical characteristics are discussed below.

Retroreflective Element

The most common retroreflective devices use either a glass-bead impregnated sheeting or cube-corner prismatic unit to provide retroreflection. In both cases, the optical elements are enclosed and sealed in a plastic housing or envelope (figure 57) to retain retroreflective properties when exposed to rain. The cube-corner units are much brighter than those with retroreflective sheeting; white retroreflectors of either type are brighter than yellow. A variety of optical elements are used by manufacturers to obtain wide-angle retroreflection.

The retroreflective inserts for PMDs are available as pressure-sensitive disks or they are mounted within an aluminum case. One version of this device is characterized by a honeycomb pattern. It provides an air gap between the top surface and the beaded layer.

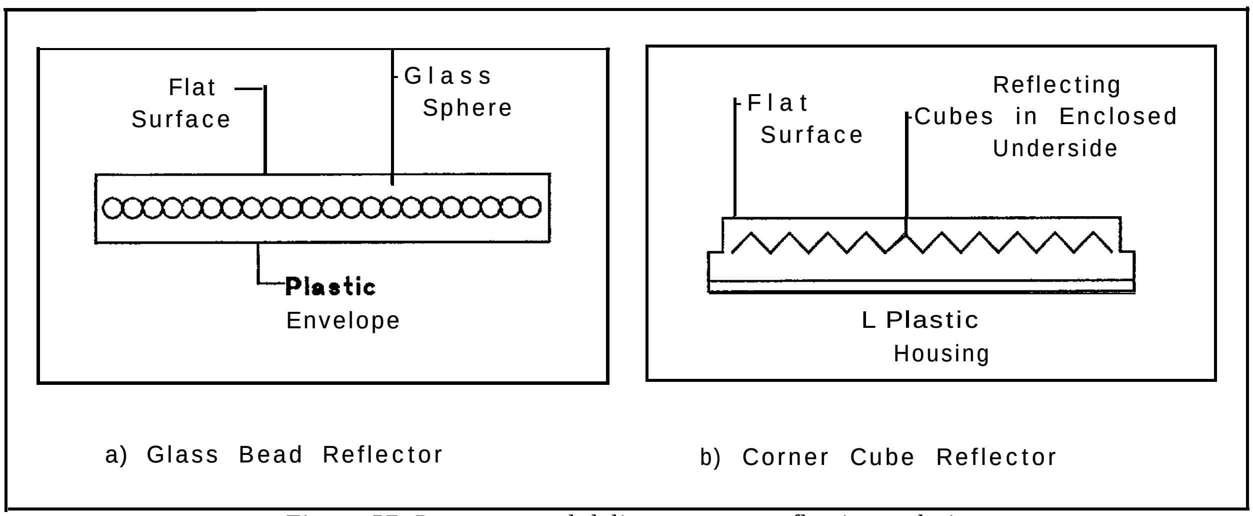

Figure 57. Post-mounted delineator retroreflective techniques

The typical cube-corner retroreflector consists of a clear and transparent plastic face covering approximately 7 square inches (4,375 millimeters squared) of retroreflective area. A plastic-coated metallic foil backing is fused by heat and pressure to the retroreflective surface. The entire unit, including the 3/16-inch (4.8-millimeter) grommet for center mounting, is permanently sealed against dust and moisture.

A new type of PMD using retroreflective sheeting for visibility is gaining popularity with the States. It consists of rectangular sheeting material attached directly to a flexible delineator post. A typical delineator post is illustrated in figure 58. These delineators are used widely because of their ease of maintenance and their ability to survive more than one impact from a vehicle.

Mounting Post

The materials of the support element of PMDs traditionally have been limited to a 3.5-inch (90-millimeter) U-channel iron post(usually galvanized), 0.75-inch (19 millimeter) standard black pipe, or 2- by 2-inch (50- by 50millimeter) timber post, preferably cedar or redwood. Because they are close to the roadway, vehicles often hit PMDs. These knockdowns present a costly maintenance problem and are a hazard to the impacting vehicle.

For these reasons, the flexible delineator posts mentioned are becoming more widely used. These new posts reduce the hazard to impacting vehicles as well as the replacement cost. The most promising approaches include impact-resistant flexible posts. A yielding system that will stay down after impact, and colored posts to help prevent impacts.

The use of flexible PMDs has grown because the cost of replacement often reached unacceptable levels. By the late 1970s for example, California had approximately 600,000 PMDs in place that required 300,000 repairs annually. Many PMDs are hit several times a year. In 1978, California budgeted almost $1.6 million for PMD system maintenance. Replacement cost ranged from $6 to $8 each.[81]

Because costs for PMD maintenance were becoming so exorbitant, the CaliforniaDOT (Caltrans) tested a number of

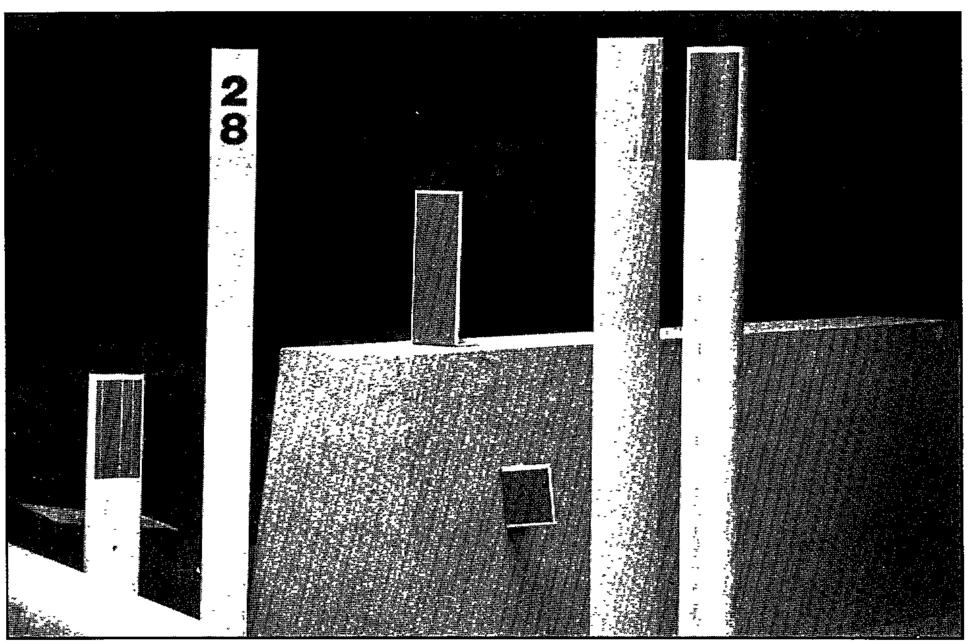

Figure 58. Typical dimensions for flexible delineator posts

commercially developed plastic posts of two basic types: driveable, and nondriveable.[82] The drivable post is forced into the ground like a metal post and requires considerably less work and time to install than the nondrivable post. Nondriveable posts are of two types: those that require back filling in the interior and around the outside of the post and those that do not. Flexible units also are equipped with retroreflective sheeting rather than prismatic buttons. This helps prevent damage to the retro-reflective unit upon impact.

Each post was subjected to up to 10 vehicular impacts at 55 miles per hour (89 kilometers per hour). Although some posts reacted better than others, the test program conclusively demonstrated that impact-resistant plastic delineation posts are a viable alternative to rigid steel posts.

After the 1978 study, Caltrans recommended flexible posts where the life of a metal post is less than one year. Locations with short radius curves and high approach speeds also warrant their installation.

Since Caltrans's early tests, many commercial models of flexible PMDs have become available. Many States use these delineators, and some have created their own designs. A Colorado study tested six different models of flexible delineators by subjecting them to both warm and cold weather impact tests as well as a one-year roadside evaluation.[83] The results were used to determine a cost-per-hit index based on delineator initial and replacement costs. A specification for use in Colorado is proposed for the testing and prequalification of flexible delineator posts.

The Wyoming Highway Department, in cooperation with the FHWA, developed a two-part delineator post that has no recoil and stays down after impact. The anchor is a triplex socket consisting of a shaft and stabilizer fins to hold it rigid in the ground. The post, which slips into the anchor, may be a 1 1/2-inch (37.5-millimeter) outer-diameter thin-walled electrical metal conduit or a 1 l/2-inch (37.5-millimeter) inner-diameter high-density polyethylene tubing fitted over a 24-inch (61-millimeter) metal conduit.

Three holes are punched in the pipe 4 inches (102 millimeters) from the bottom to ensure that it will lie flat when hit. A small portion of the pipe is bent rather than broken, which keeps the pieces together and prevents them from flying through the air after impact.

The electrical metal conduit may be reused up to three times when installed in areas with speed limits of 40 miles per hour (64 kilometers per hour) or less. The broken end is simply cut square, new holes are punched, and the post is reinserted in the anchor. The polyethylene assembly may be reused a number of times by replacing the 24-inch (610-millimeter) metal sleeve.

Wyoming estimated a cost of $3.25 per unit for the metal conduit post and $4.25 for the polyethylene unit Labor included, the total cost should be about $4.50 and $5.75, respectively. The cost of replacement, including labor, is expected to be less than $2.00 per unit. The Wyoming Highway Department has recommended that other highway agencies consider implementation of this system as a safe and cost-effective alternative to the steel post.[80]

PERFORMANCE

When rated for visibility and durability, most PMDs rate highly in both categories. The cube-corner retroreflector provides more nighttime brightness than reflective sheeting, but both provide adequate long-range delineation PMDs usefulness is particularly evident in adverse weather and low visibility conditions. They are not effective in areas with moderate to high ambient light levels; they are not recommended for use with reliable fixed roadway illumination.

Roadway film and dirt have an important effect on the performance of PMDs. A field study conducted in Australia showed that dirt accumulation and aging could reduce night visibility from about 1,000 feet (305 meters) to 100 feet (30.5 meters) under low-beam headlights.[84] This is not a permanent condition; washing the retroreflectors is possible. Rain will also clean them to some extent.

PMDs have long service lives provided they are kept clean and are not damaged by encroaching vehicles. A PMD can be expected to obtain a service life of about 10 years if knockdown or vandalism do not occur.

INSTALLATION AND MAINTENANCE

PMDs can be cost-effective if they are installed and maintained correctly. This section will discuss some recommended procedures for these operations.

Spacing and Placement

In tangent sections PMDs should be placed 200 to 500 feet (61 to 153 meters) apart in a continuous line not less than 2 feet (0.6 meters) or more than 8 feet (2.4 meters) outside the edge of the usable shoulder. Delineators should also be placed on the outside of curves having a radius of 1,000 feet (305 meters) or less, including medians in divided highways and freeway ramp curves. The recommended spacing for delineators on curves is given in table 13. Three PMDs should be placed in advance of the curve and three beyond the curve. Curve spacing should be such that three PMDs are always visible to the driver. The spacing of delineators on curves should not exceed 300 feet (90 meters) or be less than 20 feet (6 meters). A typical installation is shown in figure 59.

Recently, an analytical computer optimization of the height, spacing, and lateral offset of PMDs for tangent sections and horizontal curves on two- and four-lane roadways was performed in Ohio.[84] The project included a small-scale field demonstration and evaluation. The study concluded that PMDs with 18 square inches (116 centimeters squared) of encapsulated lens sheeting material with a specific intensity per unit area (SIA) of 309 candelas per foot-candle per square foot should be placed every 275 feet along tangent sections of four-lane divided highways. PMDs with prismatic sheeting material, with SIAs of 825 and 1,483 candelas per foot-candle per square foot, should be placed every 350 and 400 feet (107 and 122 meters). These values for SIA are to be measured at an entrance angle of -4 degrees and an observation angle of 0.2 degrees.

The study presents the mathematical relationships from which optimum spacing can be calculated for curves of any radii on two- and four-lane roadways. These are repeated here for convenience in table 14. Height and lateral offset effects on visual detection are negligible for typical placements of PMDs.

Retroreflective Element Installation

Conventional roadside PMDs are formed by affixing a 3-inch (75-millimeter) retro-reflective button on the face of a 4-foot (1.2-meter) delineator post. Retroreflective buttons also may be placed on 8- by 24-inch (203- by 610-millimeter) metal target plates. The target plate should have one, two, or three holes drilled for fastening the retro-reflector to the plate with aluminum rivets.

If the center-mounted retroreflective unit is to be enclosed in an aluminum back case, the retroreflector is slipped into the rim of the case and snapped into place for permanent locking (figure 60).

The circular, enclosed, honeycombed, plastic retroreflective sheeting disk is pressure sensitive and is applied simply by removing the backing and pressing it into place on the target.

Table 13. Suggested spacing for delineators on horizaontal curves

Curve Radius, R	Spacing on Curve, S*	Spacing Before and Beyond		
		1st PMD 2S	2nd PMD 3S	3rd PMD 6S
50 ft (15 m)	20 ft (6 m)	40 ft (12 m)	60 ft (18 m)	120 ft (37 m)
150 ft (46 m)	30 ft (9 m)	60 ft (18 m)	90 ft (27 m)	180 ft (55 m)
200 ft (61 m)	35 ft (11 m)	70 ft (21 m)	105 ft (32 m)	210 ft (64 m)
250 ft (76 m)	40 ft (12 m)	80 ft (24 m)	120 ft (37 m)	240 ft (73 m)
300 ft (92 m)	50 ft (15 m)	100 ft (31 m)	150 ft (46 m)	300 ft (92 m)
400 ft (122 m)	55 ft (17 m)	110 ft (34 m)	165 ft (50 m)	300 ft (92 m)
500 ft (153 m)	65 ft (20 m)	130 ft (40 m)	195 ft (59 m)	300 ft (92 m)
600 ft (183 m)	70 ft (21 m)	140 ft (43 m)	210 ft (64 m)	300 ft (92 m)
700 ft (214 m)	75 ft (23 m)	150 ft (46 m)	225 ft (69 m)	300 ft (92 m)
800 ft (244 m)	80 ft (24 m)	160 ft (49 m)	240 ft (73 m)	300 ft (92 m)
900 ft (275 m)	85 ft (26 m)	170 ft (52 m)	255 ft (78 m)	300 ft (92 m)
1,000 ft (305 m)	90 ft (27 m)	180 ft (54 m)	270 ft (82 m)	300 ft (92 m)

$* S = 3\sqrt{R - 50}$

Table 14. Equations for calculating optimum PMD spacings

Type of sheeting	Assumed Value for Specific Intensity (candelas per foot candle per square foot)	Type of Highway	Spacing Equation*
Encapsulated Lens	309	Two-Lane	$10*(R-43)^{1/3}$
Prismatic	825	Two-Lane	$11.5*(R-44)^{1/3}$
High-Intensity Prismatic	1483	Two-Lane	$13*(R-46)^{1/3}$
Encapsulated	309	Four-Lane	$9.8*(R-40)^{1/3}$
Prismatic	825	Four-Lane	$11.5*(R-45)^{1/3}$
High-Intensity Prismatic	1483	Four-Lane	$13.5*(R-47)^{1/3}$

* - In these equations, R equals the radius of the curve

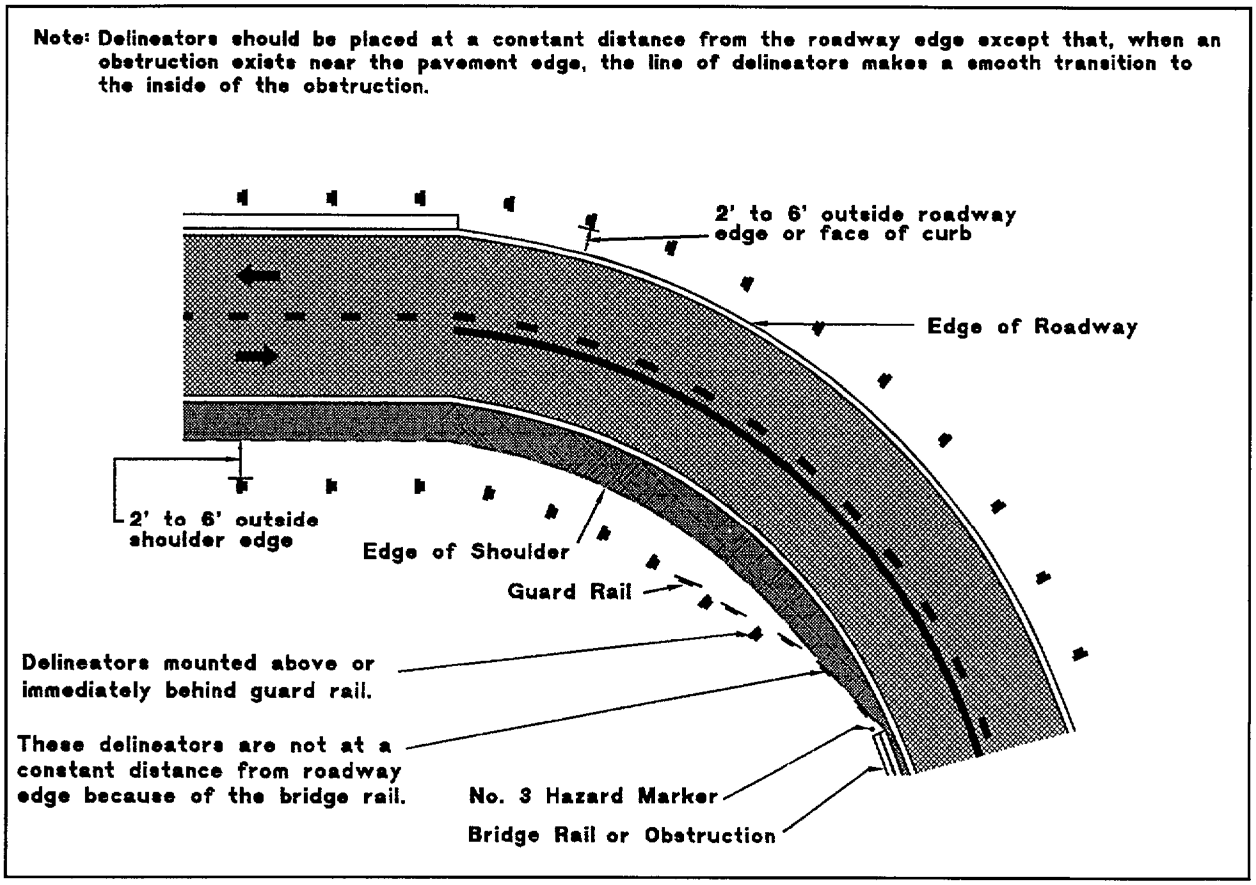

Figure 59. Typical delineator installation on horizontal curve.

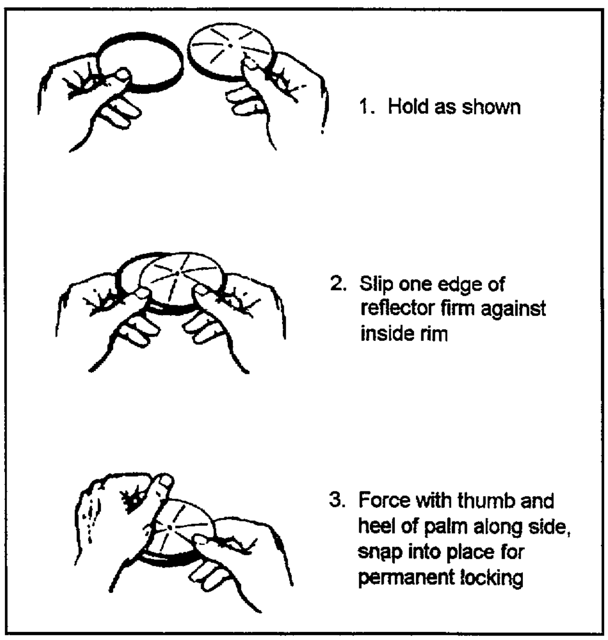

Figure 60. Encasing center-mount retroreflector in aluminum back case

Post Installation and Equipment

Special equipment is available to mechanically drive the steel post into the ground. This is expensive equipment, usually used only for large installations. Normally, maintenance forces will install the posts with a hammer and driving head or with some form of top-weighted driving head that has handles on each side to exert the necessary downward force.

Posts are usually driven 2 feet (0.6 meters) below the surface, with 4 feet (1.2 meters) remaining above the pavement at the outer edge. Figure 61 is a cross-section of delineator placement with and without a curb.

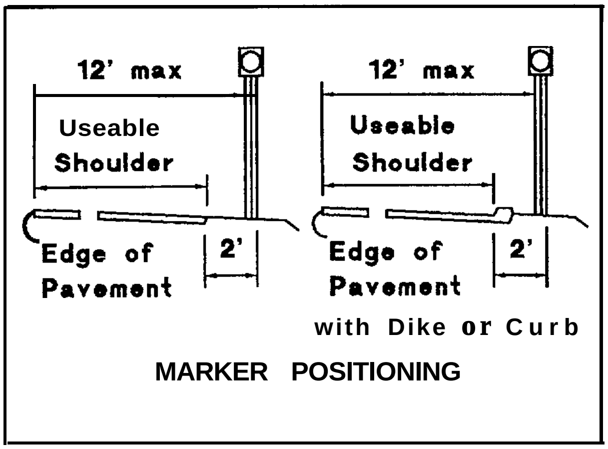

Figure 61. Typical delineator positioning

Replacement

PMDs are highly susceptible to knockdowns, vandalism, and theft. Bent or missing PMDs that obviously need attention should be repaired promptly. This is urgent when the bent or knocked-down post protrudes in or near the roadway.

PMDs' long service lives sometimes cause agencies to overlook their maintenance. Prompt replacement of missing PMDs or damaged posts is important to avoid future costs. In extreme weather, PMDs often are the only means of guidance available to the driver. These devices have high priority for installation; therefore, an equally effective level of maintenance should be maintained.

Cleaning

Road film and dirt can ruin the visibility of PMDs. This happens even to units that perform well when they are clean. Some highway agencies have developed methods for washing these retroreflectors during dry periods. These techniques range from simple watering under pressure to a complete revolving brush device.

Winter Maintenance

PMDs also are vulnerable to damage from heavy snowdrifts, snowplows, or other roadside maintenance vehicles. Maintenance crews should repair posts that are hit inadvertently by equipment doing other maintenance activities.

In high snowfall areas, the condition of PMDs should be observed at the end of the snow season. Replacement and maintenance should be scheduled for damaged PMDs.

Before the snowfall season, some highway agencies install snow poles to extend above the top of the expected snow drift. Attaching the snow pole is a simple procedure. It is done with two brackets, and their associated bolts and washers, which fit existing holes. The removal of extended snow poles in the spring can be combined with cleaning, replacement, or other PMD maintenance.

Crew Size and Safety

Maintenance for PMDs requires neither a large crew nor complex equipment. Because the posts are located slightly off the shoulder, some crews tend to forego proper safety procedures for the work. Whereas lane closure or coning may not be required in all cases, workers should be protected by signing or a strategically placed service vehicle, or both. Vehicles encroaching the shoulder should be properly marked with work zone devices.

Colored Posts

It is obvious that both the safety hazards and replacement costs associated with repair of knocked-down posts would be eliminated if the post was not hit in the first place. Recognizing this fact, several highway agencies have experimented with using a colored delineator post in an attempt to prevent knockdowns.

Sign post tests conducted in Houston, Texas, indicated a 49 percent increase in daytime visibility distance and a 30 percent increase at night.[86] Knockdowns decreased from 24 to 10 sign posts in a 20-month before-and-after study. Later studies at different sites in Texas have reported a 50 percent reduction in knock-downs. After a year of testing, yellow sign and delineator posts became standard in Texas and have attracted interest nationally.

Removal

Removal of PMDs usually is not necessary. Normally, the retroreflective units are normally replaced and the posts left in place. Removal occurs only when the post is struck by a vehicle. If a construction project or other program does require removal of a PMD, standard steel post PMDs can make the removal operation difficult. Removal of these standard PMDs will require equipment and can be costly.

Removal cost is another reason that the flexible post PMD is becoming popular. Many of these devices are mounted in a premade hole in the ground to the side of the pavement. Removal consists of simply rotating the post one quarter-turn by hand and lifting it from the hole.