

# CHAPTER M

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**M1.00 Introduction (Family Problems M1, M2, M3)**

This Chapter covers all work to replace and maintain roadway delineation and pavement markings/markers.

It includes work in the following Family/Problem areas:

- M1 Pavement Striping
- M2 Pavement Markings
- M3 Raised Pavement Markers
- M9 Inventory Updating (portion)

Typical work on pavement delineation and markings may include the following:

- (A) Inspection of pavement delineation
- (B) Layout for replacement purposes
- (C) Refurbishing delineation
- (D) Replacement of missing markers
- (E) Repainting of red curbs where it is a State obligation

Work in the “M” Family includes only pavement marking and delineation on the traveled way, shoulders, ramps, and auxiliary lanes. It does not include markings, legends, parking stalls, or at roadside rest areas, weigh stations, and other public service locations. Work in such areas should be reported to the “G” Family, Public Facilities.

The Traffic Manual has been replaced by the California Manual on Uniform Traffic Control Devices, herein referred to as the MUTCD. Contact the Division of Traffic Operations or the Division of Maintenance for additional information or advice on the MUTCD. Attention is directed to the Division of Traffic Operations homepage for the Office of Traffic Engineering.

Signs referenced with (CA) in this chapter indicate a California sign code. Otherwise, the sign code referenced is a Federal sign code.

**M1.01 Levels of Maintenance**

**(A) Inspection**

A formal night inspection of all pavement delineation condition shall be completed once each year between April 1<sup>st</sup> and May 15th. Results of the pavement delineation condition inspection shall be recorded and utilized to develop the work plan. Date of inspection and scheduled restoration shall be included in the records.

**(B) Pavement Stripes and Markings**

Pavement stripes and markings should be renewed when, in the judgment of the Supervisor or District Traffic Operations, they have lost their effectiveness. The Assigned Supervisor shall have the primary responsibility for identifying deficiencies. All employees, however, should be instructed to report observed deficiencies.

**(C) Missing or Ineffective Pavement Markers**

Missing or ineffective pavement markers that significantly affect configuration of the Line should be considered for replacement. Whenever possible, replacement should be scheduled in conjunction with other Maintenance operations to minimize disruptions to traffic.

A formal night inspection of all pavement delineation and markers shall be completed once each year between April 1<sup>st</sup> and May 15th. If specifically requested, results are reported to the Headquarters Division of Maintenance HM4 Program Advisor. All results shall be reported on form MTC-0108 (Highway Facilities Night Inspection). When reports are not requested, the records should be kept on file for a minimum of three (3) years. Routine or informal delineation inspections are performed on an "as-needed" basis, or under the general guideline of twice a year. Informal delineation inspections are not reported to the Headquarters Division of Maintenance.

The purpose of the formal night delineation inspection is to help the Department prioritize and schedule future workload and replacement needs.

The formal night delineation inspection shall be performed between April 1st, and May 15th every year. Factors that need to be considered are workloads and weather.

The Supervisor of the striping crew or the Special Crews Superintendent shall have the primary responsibility for detecting and reporting delineation deficiencies. However, all Caltrans Maintenance employees should be instructed to report damaged, non-performing, or obliterated delineation and markers whenever noted.

District Traffic Operations may also aid in determining the adequacy of pavement delineation and markers.

The following are general guidelines for performing delineation inspections at night:

- (A) It is important that the inspection vehicle headlamps be properly adjusted. Headlamps should be in the low-beam position for night inspections.
- (B) Night delineation inspections should not be completed during inclement weather, or when water, debris, or dirt obscures the markings. These conditions may affect the outcome of the inspection and may contribute to a negative rating of the performance. These conditions are difficult for properly performing delineation and marker inspections. A false negative performance review may cause the Department to use resources where it is not needed.
- (C) Conduct inspections safely. Try to blend with the flow of traffic. If it is absolutely necessary to slow or stop on the shoulder close to the traveled way, use a flashing light, amber rotating light, or light bar. A hard hat and reflective vest shall be worn if the inspector leaves the inspection vehicle. Please refer to the current Code of Safe Operating Practices (CSOP) for required and suggested personal safety equipment for night work.
- (D) The inspection team shall consist of a minimum of two (2) employees. One member of the team should be from the district's striping crew. Other potential team members are personnel from the raised pavement markers crews or local maintenance crews. District Traffic Operations employees should also be invited to participate in these annual reviews.
- (E) It is not necessary that inspectors have perfect 20/20 vision. It is necessary, however, that at least one team member have good color vision for evaluating delineation colors.
- (F) Delineation should be observed at the "distance of driver need". This distance varies depending on factors such as posted speed and roadway alignment. However, for the average highway, observers should be focusing attention on delineation and markers at about 250 ft. ahead of the vehicle. For city streets, where posted speeds are generally lower, delineation observations may be made closer to the vehicle.
- (G) The inspection vehicle should normally be driven in the outside lane of multilane highways. This is generally the safest path of travel for the night inspection team.

The adequacy of retro reflectivity is not based on specific levels of brightness. Rather, it is based on the best judgment of the night inspection team to determine whether reflectivity is

above or below 50%. Typical questions to consider when making decisions regarding delineation adequacy are:

- (1) Is the geometry of the Roadway making it difficult to see the pavement markers or delineation?
- (2) Type of material needed at location. Thermo plastic or paint.

The Night Inspection report for delineation and markers needing restoration/replacement must be completed accurately to assure that appropriate corrective action will be taken. Budgeting, staffing, and work scheduling are typical uses of reported data.

### **M1.02 Responsibility**

When needed, the existing pavement delineation pattern shall be replaced with the identical delineation pattern. There shall be no deviation from the standards illustrated or written in the MUTCD, and no traffic stripe or raised markers shall be placed except at locations indicated in that manual without direction from District Traffic Operations. Installation Orders provided by District Traffic Operations for placement of new or modified delineation shall show the location and type on a print, authorized by Deputy District Director, Traffic Operations. Questions regarding Installation Orders should be directed to District Traffic Operations. It is acceptable to substitute materials different from the original material being replaced, such as thermoplastic instead of water-borne paint, or thermo-plastic in place of non-reflective raised pavement markers.

Maintenance of signs and pavement markings placed off the right of way for roads entering the State highway may be an obligation of the Department when they are placed primarily for the protection of traffic on the State facility. Examples are pavement markings that support the R1-1 STOP and W3-1 STOP AHEAD signs. It is standard practice for the owner of the entering facility to fund the initial installation. Future maintenance costs, including clearing of trees and brush to improve visibility of signs, should be borne by the Department.

Districts are responsible for the placement and maintenance of limit lines (stop bars) at both existing and new paved approaches to a State highway. Only those "STOP" pavement markings requested by District Traffic Operations should be maintained. Districts will coordinate the work of the pavement marking and sign crews for these installations. The preceding instruction is not intended to preclude establishment of Maintenance Agreements whereby local agencies assume these responsibilities.

Where local governmental agencies have been delegated pavement delineation responsibilities by Maintenance Agreement, their performance shall conform to the standards set forth in this chapter. The district must periodically inspect delineation to assure that local agencies are maintaining acceptable standards.

### **M1.03 Safety**

It is the responsibility of all Caltrans highway Maintenance personnel to understand and follow the rules written in the Code of Safe Practices and any other safety laws, rules, Policy and Procedures, and safety guidelines, pertaining to the work being performed.

Employees shall be provided with, and shall wear, required personal protective equipment applicable to the work being done. Before work starts, Material Safety Data Sheets (MSDS) for any substances used shall be reviewed, and all crew members made aware of any potential toxic hazards in the work. Pavement delineation equipment, including appropriate support equipment, shall be maintained and operated in a manner that promotes good safe practices, does not pose a hazard to other employees or the general public, or to the environment.

Thermoplastic material heated to excessive temperatures can flash and splatter when the material is drawn and exposed to air. Temperature gauges mounted on thermoplastic application equipment shall be checked at frequent intervals. Equipment found to have defective temperature gauges shall not be used until repaired.

While removing or applying pavement delineation, all traffic control and worker protection shall conform to Chapter 8 of this manual, Protection of Workers.

### **M1.04 Layout**

The term “layout” refers to the process of placing reference marks on the pavement to be used as a guide for locating pavement delineation on the roadway surface.

Reference marks may also occasionally be located on curbs or sidewalks. In snow areas, saw cuts in the pavement can be used to identify the location of left turn lane pockets. Pictures of pavement delineation can also provide a valuable reference for replacement in kind. Reference marks are a guide for placement of pavement delineation and are not to be used as temporary lane line.

### **M1.05 Pavement Delineation on Resurfaced Areas**

#### **(A) Requirement for Replacement of Pavement Delineation**

All lane line pavement delineation that has been covered must be replaced (permanent or temporary) at the end of the operation each day. The person in charge of the field operation will be responsible to take proper action to assure that the correct type of pavement delineation is placed within the required time frames.



- (1) Permanent pavement delineation covered by Maintenance or Construction activities should be replaced within one (1) week and shall be replaced within two (2) weeks. In the interim, “short-term” delineation measures shall be used.. Contact District Traffic Operations or the Headquarters Maintenance Division for the latest instructions.
- (2) Temporary lane lines shall be placed before leaving the job site, if permanent delineation cannot be restored by the end of the work shift. Various types of day/night raised retroreflective markers are approved for short-term use. These markers are to be placed on not more than 24-ft. centers on curves and tangent.

On liquid asphalt concrete patches, a temporary day/night marker, secured by butyl adhesive to a 1-ft. piece of temporary foil-backed tape, has proven capable of staying in place while the patch cures.

**(B) Specific Instructions for Placement of Signs**

- (1) On two lane conventional highways where no passing-zone lane line has been covered, a sign package consisting of a W20-1 ROAD WORK AHEAD and an R4-1 DO NOT PASS sign shall be posted within 1000 ft. of the no passing zone. The R4-1 DO NOT PASS sign should be posted at 2,000 ft. intervals throughout the extended no-passing zone. The R4-2 PASS WITH CARE sign should also be placed at the end of the zone.
- (2) On seal coats more than two (2) miles in length, the above instruction could be modified by posting a W20-1 ROAD WORK AHEAD sign at each end of the job, supplemented with a W7-3a NEXT XX MILES black on orange plate below the sign.

If a no-passing zone is continuous throughout the seal coated area, an R4-1 DO NOT PASS sign shall be placed at the beginning of the zone and at maximum 2,000 ft. intervals.

- (3) Obliterated edge lines are not to be replaced with temporary dashes or retroreflective markers. When edge line delineation is required because of narrowing pavement or curvilinear alignment, portable delineators (guide markers) may be used to guide traffic.

**(C) Delays in Placement of Permanent Pavement Delineation**

It is understood that equipment breakdown, weather, or other problems may unavoidably delay placement of permanent pavement delineation. It is important that the reason for delay be documented and filed with the project files.

(D) Exceptions to the Two Week Time Limit

Exceptions to the 2-week time limit to restore permanent delineation are as follows:

- (1) Cure time of pavement before placing raised markers.
- (2) Winter conditions where pavement delineation cannot be maintained due to rain snow, plowing, etc.
- (3) Short patches that are less than 500-ft. Long on tangent alignment where the pavement is visible when entering the patch from either direction. This exception is intended for only single patches not placed in close proximity to another.

Under no circumstances shall a job site be left without at least temporary delineation and or signs as noted above.

**M1.06 Pavement Delineation Removal**

The acceptable methods of removing pavement delineation are horizontal rotary grinding, sandblasting, and hydro blasting.

When using either of these methods to remove legends, the entire pavement surface within the area of the legend shall be removed. Failure to remove the surface of the entire legend area can result in the former message being conveyed by the resulting scar on the pavement surface.

Paint or asphalt emulsion shall not be used to cover pavement delineation except as a temporary measure until permanent repairs can be made. A general guideline for temporary is six (6) months or less. Pavement that has been covered with paint or asphalt emulsion for more than six (6) months should be scheduled for permanent removal when workload allows. The crew supervisor, in consultation with the Superintendent, shall determine if permanent removal is more appropriate than a temporary cover of the pavement delineation when the Installation Order is issued by the District Traffic Operations unit.

Raised markers are sometimes removed on small jobs using hand tools such as pry bars, hammer and screwdriver, or chisel. Large removal projects can best be accomplished by utilizing a special attachment on a motor grader.

### **M1.07 Environmental Concerns**

Caltrans districts will be responsible for monitoring and acting as independent agents in dealing with local air quality control districts. The California Environmental Protection Agency (Cal/EPA) may override local district rulings.

Residue of paint from color changes or cleaning tanks is to be handled as a hazardous waste.

Paint guns shall not be purged on shoulders. Each Caltrans district should follow established procedures adopted in their area for picking up and disposing of these materials.

Current law provides that individual employees may be held personally liable for penalties assessed for willful or negligent infractions of these rules. Caltrans will take disciplinary action against employees who violate hazardous waste disposal laws, up to and including termination of employment.

### **M1.08 Recessed Delineation Materials**

Grinding slots in the pavement and placing recessed markers and/or thermoplastic material in those slots has greatly extended the life of pavement delineation in some areas. Materials installed in the recessed areas include retroreflective pavement markers and thermoplastic, Tape, or MMA. Typical areas selected for this type installation include highways with high weave/heavy traffic and snow removal conditions.

### **M1.09 Longitudinal Pavement Markings**

- (A) Longitudinal pavement markings serve the following specific traffic guidance functions:
- (1) Single broken white line is used to delineate the edge of a traffic lane where traffic is permitted in the same direction on both sides of the line.
  - (2) Single broken yellow line is used to delineate the left edge of a traffic lane where overtaking with care is permissible for traffic in either direction of travel.
  - (3) Single solid white line is used to delineate the edge of a traffic lane where travel in the same direction is permitted on both sides of the line, but crossing the line is discouraged. It is also used to mark the right edge line.

A wide solid white line is used for emphasis where crossing it requires unusual care. It is also used as a line to delineate turnouts, left or right turn lanes, and bicycle lanes.

- (4) Single solid yellow line delineates the left edge line of each roadway of divided streets or highways, one-way roadways, and ramps in the direction of travel.
- (5) Double yellow line consisting of a single broken yellow line and a single solid yellow line delineates a separation between traffic lanes in opposite directions where overtaking with care is permissible for traffic adjacent to the broken line, and is prohibited for traffic adjacent to the solid line.

This pattern is also used to delineate a two-way left turn lane in which the solid line is placed on the outside. Traffic adjacent to the solid line may cross this marking with care only as part of a left turn or U-turn maneuver.

- (6) Double line consisting of two (2) solid yellow lines delineates the separation between traffic lanes in opposite directions where overtaking is prohibited in both directions. It is used as a channelizing line in both directions. It is frequently used as a channelizing line in advance of an obstruction that must be passed on the right. Black paint should be used between the yellow stripes to improve definition and maintain the interior gap during repainting.
- (7) Dotted line may be used to delineate the extension of a line through an intersection or an interchange area. The dotted line shall be the same color of the line it extends.

More information on this subject is included in Part 3 of the MUTCD, and in the Standard Plans.

### **M1.10 Pavement Markings - General**

Pavement markings are used to supplement traffic signs conveying messages or directions to the motorist, particularly at locations where pavement width or dense traffic prevent motorists from seeing the signs readily.

Approval of District Traffic Operations must be obtained before using other than standard markings.

District Maintenance will continue to work with District Traffic Operations to identify pavement markings that are obsolete and should not be maintained. Documentation is required from District Traffic Operations before maintenance of pavement markings is waived. A District Traffic Operations Installation Order (IO) will be required prior to removal by grinding or other methods of any pavement markings.

Stencils used to place pavement markings shall be of uniform dimension. The California standard is shown in the Standard Plans, Plates A-24A through A-24E.

Additional information regarding pavement markings is included in Part 3 of the MUTCD.

### **M1.11 Pedestrian Crossings**

Attention is directed to Part 3 of the MUTCD. Pedestrian crosswalk markings may be placed at intersections, representing extension of sidewalk lines or on that portion of the roadway distinctly indicated for pedestrian crossing. Crosswalks and related pavement markings will be painted white or yellow depending on location. Crosswalk markings serve primarily to guide pedestrians in the proper paths.

Pedestrian crosswalk markings should not be used indiscriminately. Unwarranted crosswalks can be detrimental to pedestrian safety by providing a false sense of security.

Replacement by highway Maintenance personnel of crosswalks at intersections of local streets with State highways shall be confined to State highway surfaces. Where possible, this work should be delegated to local authorities under a cooperative Maintenance Agreement.

When markings are to be covered by resurfacing, the District Traffic Operations should be requested to review the project for removal of markings that are no longer necessary or are redundant.

### **M1.12 School Area Pedestrian Crossings**

Attention is directed to Part 7 of the MUTCD. Pedestrian crosswalks and related pavement markings will be painted yellow or white, depending on the location of the school building or grounds with respect to the highway. In this regard, Section 21368 of the California Vehicle Code provides as follows:

Whenever a marked pedestrian crosswalk has been established in a roadway next to a school building or the grounds thereof, it shall be painted or marked in yellow, as shall be all the marked pedestrian crosswalks at an intersection.

Other established marked pedestrian crosswalks, may be painted or marked in yellow, if either (a) the nearest point of the crosswalk is not more than 600 ft. from a school building, or the grounds thereof, or (b) the nearest point of the crosswalk is not more than 2,800 ft. from a school building, or grounds thereof, there are no intervening crosswalks, other than those next to the school grounds, and it appears that the circumstances require special painting, or marking of the crosswalk, for the safety of persons attending the school.

There shall be painted or marked in yellow on each side of the street in the lane or lanes leading to all yellow marked crosswalks the following words, "SLOW--SCHOOL XING." Such words shall not be painted or marked in any lane leading to a crosswalk at an intersection controlled by stop signs, traffic signals or yield right of way signs. A crosswalk shall not be painted or marked yellow at any location other than as required or permitted by this section.

All school pavement delineation shall conform to Part 7 of the MUTCD. Sign installation should be coordinated with delineation placement.

### **M1.13 Transverse Markings**

Transverse markings which include shoulder markings, word and symbol markings, limit lines (stop bars), crosswalk lines, markings for highways patrolled by aircraft, parking stall markings, and others shall be white, except for yellow markings near schools as provided in Part 7 of the MUTCD. Transverse median markings shall be yellow.

### **M1.14 Parking Regulation Curb Markings**

Section 21458 of the Vehicle Code authorizes the use of paint on curbs to show parking regulations. The following colors shall be used as indicated.

Red	No stopping, standing, or parking.
Yellow	Loading.
White	Stopping for loading at specified times.
Green	Short time limit parking.
Blue	Indicates parking limited exclusively to the vehicles of persons with disabilities.

Painting and maintenance of curb markings to show parking regulations are the responsibility of the local agency. An exception occurs when curb markings have been installed at the request of the State to meet traffic operational and/or safety needs. This type of work should be delegated to local agencies by means of Maintenance Agreements.

### **M1.15 Limit Lines (Stop Bars)**

Limit lines (CVC377) are solid white lines, normally 12 inches to 24 inches wide, extending across all approach lanes to indicate the point behind which vehicles are required to stop.

If a marked crosswalk is in place, it would normally function as a limit line. For added emphasis, a limit line may be placed 4-ft. in advance and parallel to the crosswalk line nearest approaching traffic.

In the absence of a marked crosswalk, the limit line should be placed at the desired stopping point. This point is typically no more than 30-ft., nor less than 4-ft. from the nearest edge of the intersecting roadway.

If a limit line is used in conjunction with a stop sign, it should ordinarily be placed in line with the STOP sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the limit line should be placed at the stopping point.

A limit line shall be placed on paved approaches to State highways, and a "STOP" pavement marking may be placed if specifically requested by the District Traffic Operations.

#### **M1.16 Parking Stall Markings**

The placement and maintenance of parking stalls is the responsibility of the local agency. An exception to the above practice may be made when a State highway-resurfacing project covers existing parking lines. In this case it is the responsibility of the Department for replacement of the parking markings. Parking stall markings shall be white. Refer to Part 3 of the MUTCD for details of parking stall layout.

#### **M1.17 Pavement Arrows**

Primary use of pavement arrows is at freeway entrance and exit ramps, turn lanes and lane reduction locations. Type of arrow and proper location can be found in Part 3 of the MUTCD.

#### **M1.18 Railroad and Light Rail Crossings**

Attention is directed to Part 3, Part 8, and Part 10 of the MUTCD. Pavement markings are to be placed and maintained at all railroad and light rail grade crossings on State highways, including spur tracks.

Railroad grade crossing pavement markings shall also be placed in each approach lane in advance of every light rail grade crossing where automatic gates or flashing lights are present.

### **M1.19 Miscellaneous Markings**

Instructions for proper placement and stencil design for the following markings are found in the MUTCD:

- (A) Speed Enforcement by Aircraft
- (B) High Occupancy Vehicle Lanes
- (C) Bike Lane Markings
- (D) Disabled Persons Parking Symbol
- (E) Cattle Guard Crossings  
(Work on cattle guard crossings is to be reported to “C” Family, Slopes/Drainage/Vegetation).

### **M1.20 Material**

All pavement delineation materials used to guide or control vehicular and pedestrian traffic on the State highway system shall be approved by the Engineering Service Center, Office of Materials Engineering and Testing Services. Test sections of new materials may be placed with concurrence of Headquarters Division of Traffic Operations.

### **M1.21 Traffic Paint**

The paint currently used for pavement delineation is water-borne, and is available in white, yellow, and black.

Traffic paint is available in bulk containers called “totes” (approximately 345 gallons), 55 gallon barrels, and 5 gallon buckets.

Waterborne paint should not be stored where it may be exposed to repetitive freeze/thaw cycling.

Waterborne paint shall be applied at a thickness of 15 millimeters.

High build paint shall be applied at a thickness of 25-30 millimeters.

When water-borne traffic paint is used, two (2) coats of paint are not required, except on chip seals.



For chip seals, one (1) coat of paint shall be applied in each direction of travel. Both coats shall be beaded. Care should be exercised that recommended application rates for water-borne paint are not exceeded. Applying water-borne paint too heavily will cause the paint to chip.

	Gallons Per Mile	Gallons Per Mile	Pounds Per Mile	
<b>Delineation</b>	<b>Waterborne</b>	<b>High Build</b>	<b>Thermo</b>	<b>Glass Beads</b>
<b>4" Broken Stripe</b>	4.125 GLs @ 15 mil thick	8.25 GLs @ 30 mil thick	385 Pounds at 80 mil	6 to 8 lbs gallon
<b>4" Solid stripe</b>	16.5 GLs @ 15 ml thick	33.0 GLs @ 30 mil thick	1540 lbs @ 80 ml thick	6# per 100 sq ft of thermo
<b>Pavement Markings</b>	1 Gl per 107 Sq Ft	1 GL per 54 Sq Ft	1 Pound per Sq Ft	6 to 8 lbs per GL of paint

Deviations from recommended application rates may occasionally become necessary to accommodate local conditions such as tracking, temperature, etc. Decisions to adjust application rates should be based on the supervisor's knowledge of local conditions, experience, and best judgment.

To achieve maximum service life from the painted traffic stripe, striping operations should normally be conducted when weather conditions conform to the following ranges of temperature and humidity. Water-borne paint should not be applied when the ambient temperature is below 50° F (10°Celsius) or when relative humidity exceeds 75 percent.

**M1.22 Hot Melt Thermoplastic**

Thermoplastic materials are the preferred pavement delineation and marking materials for all areas that are not regularly plowed for snow or mud and where the pavement is in good condition.

Thermoplastic is supplied in two generic types, depending on the type of base resin used. The 2 types, hydrocarbon and alkyd, are not compatible in the application equipment and must never be mixed. Although alkyd and hydrocarbon materials will fuse to one another on the road, they are incompatible in a melting kettle. Failure to completely clean out kettles during material change-over may cause severe equipment problems.

Both types of thermoplastic are available in granular form for spray, ribbon, or extruded application. Thermoplastic is a dry blended mixture of resins, pigments, fillers, and glass beads packaged in a meltable plastic bag.

Thermoplastic for traffic stripe is available in white or yellow colors.

Thickness of thermoplastic may be reduced to achieve a better cost effectiveness when used on pavement surfaces having a short life expectancy. The recommended minimum application rate of extruded thermoplastic is 80 - 90 mils.

### **M1.23 Cold Pre-Formed Plastic Tape**

Plastic tape comes as a complete stripe or pavement marking legend ready to be applied to the road. It may be surface applied, recessed, or rolled into the pavement on new asphalt paving projects.

This material may be considered for locations where use of tape may be cost effective compared to other alternatives. Cold weather application of tape is generally not recommended and pavement temperatures should be at least 50°F (10° Celsius). Manufacturers' instructions for allowable temperature ranges should be followed.

### **M1.24 Thermo-Applied Granular Striping System**

This material is no longer available.

### **M1.25 Pavement Markers**

Pavement markers are available in various configurations and may be surface mounted (raised) or recessed. Markers can be retroreflective or non-reflective, temporary, or permanent, and can be installed using either epoxy or bitumen adhesives. All pavement markers used must be pre-approved by Headquarters Division of Traffic Operations and tested for compliance with specifications by the Office of Materials Engineering and Testing Services.

The allowable ambient temperature range for pavement marker installation varies with the type of adhesive being used. When using bitumen adhesive, it is important that adhesive temperature during application be between 375° F (190.6° Celsius) and 425° F (218.3° Celsius).

The use of epoxy adhesive requires that traffic control be maintained for protection of the marker until the final set of epoxy takes place. This may require as much as one (1) hour of cure time. The 1:1 mixing proportion of epoxy components must be carefully controlled to achieve the best bond between the pavement surface and bottom of the marker. Minor deviations can seriously increase marker loss.

Markers of approved colors may be placed by other agencies to identify locations of special facilities such as water sources for fire protection. Permits are required for such installations.

### **M1.26 Surface Preparation**

#### **(A) Paint**

A mechanical sweeper may be used prior to paint application to remove debris from road surface. This operation may or may not be necessary, depending on amount of dirt/debris on the roadway surface. On new Portland Concrete Cement (PCC), mechanical wire brush or abrasive blasting must be used to remove curing seal and other foreign material. Use of an air line (duster) mounted in front of the paint guns on the striper has proven successful in removal of dust.

Care must be taken not to use too much air and overwork the compressor. It is an unacceptable waste of Maintenance resources to place paint or other delineation materials on areas where dirt, debris, or weeds prevents adherence of such materials to the roadway surface.

#### **(B) Pavement Markers**

Both PCC and asphalt concrete (AC) road surfaces should be clean and dry before application of adhesive. This is especially important on new PCC pavements. The contact area for markers placed over existing paint must be either abrasive blasted or the paint must be well worn to achieve a satisfactory bond.

Pavement delineation materials shall not be applied in wet weather.

### **M1.27 Inventory Updating**

Contact your District IMMS Coordinator for information about inventory updating.

### **M1.28 Supplemental Information**

#### **(A) Guidance from District Traffic Operations**

District Traffic Operations should be responsible for providing to Maintenance, current standards that can be carried on each striper and marking truck. Supervisors are responsible for assuring that the latest standards are available for performance of work. Any change in stripe or marking patterns must be in writing and approved by District Traffic Operations.

(B) Equipment Needs

Specialized equipment is required for work performed by pavement delineation crews.

The Equipment Catalog should be reviewed before submitting requests for new or replacement equipment.

## **Section 2 - Signs (Family Problem M4)**

### **M2.00 Introduction**

This section covers the maintenance of permanent signs placed on the State highway system for the purpose of warning, regulating, or guiding traffic, and is broken down as follows:

M2.01 to M2.04	General Information
M2.05 to M2.14	Sign Panel Information
M2.15 to M2.23	Sign Support Information

The Traffic Manual has been replaced by the California Manual on Uniform Traffic Control Devices (MUTCD), herein referred to as the MUTCD. Contact the Division of Traffic Operations or the Division of Maintenance for additional information or advice on the MUTCD. Attention is directed to the Division of Traffic Operation homepage for the Office of Traffic Engineering.

Signs referenced with (CA) in this chapter indicate a California sign code. Otherwise, the sign code referenced is a Federal sign code.

### **M2.01 Scope of Chapter**

Typical sign work may include the following:

- (A) Placing of posts and/or signs.
- (B) Identification of damaged or inadequate signs.
- (C) Initiation of the reordering process for replacement signs.
- (D) Preparation of accident damage reports.
- (E) Painting of steel structures supporting overhead signs.
- (F) Tightening of bolts and screws.
- (G) Assembly of sign panels for temporary use in place of badly damaged signs.
- (H) Cleaning of dirty signs.
- (I) General inspection duties.

## **M2.02 Levels of Maintenance**

Levels of Maintenance, including frequency and priority of action, are included in Maintenance Manual Volume 2, "M" Family, for budgeting purposes. Levels may vary depending on overall appropriation of funds by the Legislature. Signs not properly maintained present a poor appearance and have diminished effectiveness in authority as traffic control devices.

Periodic inspection to detect deficiencies, which require corrective action, is an important part of proper sign maintenance.

In general, signs critical to traffic safety or operations should be repaired or replaced promptly.

If prompt corrective action is not possible, a temporary sign should be installed until permanent repair or replacement can be made. Sign deficiencies not critical to traffic safety or operations should be taken care of as soon as practicable to prevent the loss of capital investment.

Sign inspection may be performed during daylight hours or at night. Effects of age, weathering, and vandalism are sometimes difficult to detect unless the sign is observed at night. A night check should be made immediately following a grass or range-land fire as heat can cause loss of retro reflectivity.

A formal night inspection of all traffic signs shall be completed once each year. The inspections shall take place between April 1<sup>st</sup> and May 15<sup>th</sup> annually. If specifically requested, results are reported to the Headquarters Division of Maintenance. When reports are not requested, the records should be kept on file for a minimum of three (3) years. Routine or informal sign inspections are performed on an "as-needed" basis, or under the general guideline of twice a year. Informal sign inspections are not reported to the Headquarters Division of Maintenance.

The supervisor of the sign crew, or the "sign person" where sign crews do not exist, shall have the primary responsibility for detecting and reporting sign deficiencies. However, all employees should be instructed to report damaged, non-performing, or obscured signs whenever noted.

District Traffic Operations may also aid in determining the adequacy of signs.

The following are general guidelines for performing sign inspections at night:

- (A) It is important that the inspection vehicle headlamps be properly adjusted. Headlamps should be in the dimmed position for night sign inspection.
  
- (B) Conduct inspections safely. Try to blend with the flow of traffic. If it is absolutely necessary to slow or stop on the shoulder close to the traveled way, use a flashing light, amber rotating light, or light bar. A hard hat and retro reflective vest shall be worn if the sign inspector leaves the inspection vehicle. Retro reflective material on the hard hat is optional.

Please refer to the current Code of Safe Operating Practices (COSP) for required and suggested personal safety equipment for night work.

(C) The inspection shall consist of a minimum of two (2) employees. One member of the team should be a qualified sign Maintenance person. District Traffic Operations employees should be invited to participate.

(D) It is not necessary that inspectors have perfect 20/20 vision. It is necessary, however, that at least one team member have good color vision for evaluating sign colors.

Decisions regarding the adequacy of borderline signs should be based on the combined judgment of the team.

(E) Signs should be observed at the "distance of driver need." This distance varies depending on factors such as average speed and roadway alignment. However, for the average highway, observations should be made 250 ft. to 500 ft. in advance of the sign. For city streets, where average speeds are generally lower, sign observations may be made closer to the sign.

(F) The inspection vehicle should normally be driven in the outside lane of multilane highways. This is generally the safest path of travel for the night inspection team. It also places the team in a position where signs hidden by vegetation will be noted. The team should not park on the shoulder to evaluate retro reflectivity of a sign unless such practice is necessary for reasons of safety (shoulder mounted signs appear brighter when viewed from the shoulder than when viewed from the traveled way).

(G) Median mounted signs may be observed from the number one lane if it is safe to do so.

(H) It may be necessary to make two inspection passes for sections of highway where both median mounted and shoulder mounted signs are to be observed. R1-1 STOP signs and W3-4 STOP AHEAD signs on county road approaches to State highways shall be checked.

(I) Do not use a spotlight to evaluate night sign retro reflectivity. The spotlight is several times brighter than vehicle headlamps. This causes false observations of sign brightness.

(J) The adequacy of sign retro reflectivity is not based on specific levels of brightness. Rather, it is based on the best judgment of the night inspection team to determine whether reflectivity is above or below 50%. Typical factors to consider when making decisions regarding sign adequacy are:

- (1) Whether the sign is difficult to see because it is in front of a lighted background (as may be the case in urban areas).

- (2) Whether there is competition for driver attention in the area of the sign. If the answer to either of these questions is "yes", a brighter sign may be needed at those specific locations.
- (3) The "degree of hazard" associated with the sign message.

The Night Inspection report for signs needing work must be completed accurately to assure that appropriate corrective action will be taken. Budgeting, staffing, and work scheduling are typical uses of reported data.

Signs that are not adequate because they are dirty or hidden by vegetation should not be reported as deficient. These signs should be noted and reported to the appropriate Maintenance Supervisor for action. Trimming or removing vegetation or relocating the sign are corrective action alternatives for hidden signs. Sign relocation requires approval of the District Traffic Operations unit.

In addition to general physical inspections of overhead signs by sign Maintenance personnel, an engineering inspection of overhead sign structures should be made at least every five (5) years. The engineering inspection includes all portions of the structure, safety devices, mechanical and electrical equipment, and other items which need attention.

Maintenance effort on major changeable message signs (permanent type) is reported to the "K" Family, Electrical. Required maintenance on steel sign structures supporting those signs are reported to the "M" Family. Small changeable message signs that are turned or opened by hand for viewing are reported to the particular Family requiring use of the sign.

### **M2.03 Reporting Requirements**

Only permanent regulatory, warning and guide sign needs are to be reported to the M4 Family for recording in the Integrated Maintenance Management System (IMMS). All operational snow signs (signs within roadside rests, park and ride lots, weigh stations, etc.), and construction zone signs are to be reported to the appropriate Family in the IMMS. Electrical work on signs is to be reported in the "K" Family. Complete Charging practice instructions for all Families can be found in Maintenance Manual Volume 2.

The Division of Maintenance has established "Activities" by Family identifying types of work performed, units of production, costs of work, and any E-FIS Project Code or an IMMS Project Code requirements. Management decisions are often based on analyses of the coded entries. Therefore, special care should be taken to assure that the coded information entered by Maintenance personnel in the IMMS is accurate.

When a sign is replaced, the new sign must essentially be the same as the one it is replacing to qualify for Maintenance funding. New installations, if performed by Maintenance or



replacement signs that are new in shape, size, or message, are upgrades, and shall be charged to improvement allocations. These must be authorized by an Installation Order issued by District Traffic Operations.

#### **M2.04 Responsibility**

Permanent signs should be installed by persons who are trained for that particular work. Sign materials are relatively delicate and are easily damaged.

An untrained person may not know proper methods of transporting or displaying sign messages, protecting sign materials, or using equipment to safely complete the installation. New installations, with the exception of temporary emergency signs, are not to be made without approval of District Traffic Operations unit. Temporary signs required by unusual conditions or restrictions may be installed without an installation order from the District Traffic Operations unit. However, such temporary signs shall be removed or covered immediately when those conditions cease to exist or restrictions are withdrawn.

Installation Orders should show location of the sign, type of sign, type of material, type of support, size of letters, and color. Questions regarding IOs should be directed to District Traffic Operations unit.

The Office of Structures Maintenance and Investigation, Division of Maintenance, is responsible for keeping an inventory of overhead and changeable message signs and providing periodic engineering investigations. Sign numbers in the overhead sign inventory are assigned by the district. The district is responsible for maintenance of overhead signs and sign structures including both routine and special work recommended by the Office of Structures Maintenance and Investigation.

A significant amount of sign damage occurs in mountain areas due to snow removal activities. It is important that this type of damage be minimized. Unnecessary damage that requires repair or replacement of signs causes waste of Maintenance resources.

It is general policy for the Department to install and maintain permanent signs on State highways within incorporated cities or counties. When possible, districts should delegate the installation and maintenance of warning and regulatory signs to cities and counties equipped to do the work.

However, the responsibility for assuring that these signs are adequately maintained remains with the State.

Maintenance of "Trailblazer" signs, which direct traffic on city or county streets and roads to the State highway system, may be performed by local jurisdictions or with State forces. Caltrans,

however, has the ultimate responsibility for maintenance of such signs placed by the State off the highway system.

The Department will normally not install or pay for the installation of parking regulatory signs within cities or counties. These signs are usually placed to inform the motoring public of ordinances and police regulations within the local agency and may have little to do with operation of the State facility.

The Department is frequently called upon to install signs for private parties, including STOP signs for subdivisions, directional signs for golf clubs, and so forth. Other State agencies, cities and counties also request signs. All such requests are referred to District Traffic Operations. An encroachment permit will be required before work is performed for or by others. Costs are billed to the requesting party.

Maintenance of signs placed off the highway right of way may be an obligation of the Department when the sign is primarily placed for protection of traffic on the State facility. Examples are the R3-1 STOP AHEAD signs placed on roads approaching the State highway. It is standard practice for Caltrans to fund the initial installation and future maintenance of such signs for existing road connections, after obtaining necessary permission from the local agencies involved.

Where a new entrance to a State highway is provided under an encroachment permit, the other agency will be responsible for initial installation of the signs. The signs will be maintained by Caltrans in the future.

Districts are responsible for the placement and maintenance of limit lines (stop bars) at both existing and new paved approaches to a State highway. A STOP pavement marking should also be placed and maintained when directed by the Traffic Branch. Districts will coordinate the work of the sign and stencil crews for these installations.

Any unauthorized sign placed on the highway right of way by a private organization or individual constitutes a public nuisance and shall be removed.

Before relinquishment of any State route to a local agency, all signs must be in good repair.

Statutes providing for relinquishment exempt only the U.S., interstate, county, and State route shields that are to be removed prior to the time the route is actually turned over to the local authorities.

### **M2.05 Sign Acquisition**

Signs listed in the Material Operations Warehouse Catalog shall be ordered through the Material Management system on a Local Request, EDP Form DAS-OBM-1001C.

Special signs, not listed in the catalog, should be ordered on a Purchase Request, Form DAS-OBM-1005 in accordance with current instructions. Except for signs placed in stock, District Traffic Operations is responsible for ordering most signs.

Attention is directed to emergency clauses in sign procurement contracts, which are available from District Sign Coordinators. Sign orders may specify either a 5-day or a 21-day emergency order. Signs made under this provision will be direct shipped to the ordering district. Under emergency orders, the sign manufacturer will make and ship signs within 5 days (or 21 days) upon receipt of a valid Purchase Order. Allow for additional time to cut Purchase Orders and transit time after signs leave the manufacturing plant. The State is charged 15 percent and 10 percent more respectively for 5-day and 21-day emergency orders. Except for temporary and emergency signs, there is minimal need, if any, for Maintenance personnel to fabricate signs.

### **M2.06 Selection of Signs**

The broader use of symbol signs, in preference to word messages, is desirable. Educational plates accompany some symbol signs to explain in words the meaning of the new symbol.

Unless otherwise directed by the Traffic Branch, educational plates should remain in place for at least three (3) years after initial installation. No special effort will be made to remove educational plates as long as they are in serviceable condition.

Signs placed on State highways must comply with provisions of the Vehicle Code and other Statutes. The basic requirements of a highway sign are that it be legible and understood in time to permit a proper response.

Only warning, regulatory, or construction signs may be supplemented by flashing beacons.

### **M2.07 Classifications of Signs**

Highway signs are grouped into four general classifications: Warning, Regulatory, Guide, and Construction (a.k.a., Temporary Traffic Control or TTC signs). Designated shapes and colors are used to differentiate between the different sign classifications. Persons installing signs must make certain that the distinctive silhouette shape of a sign is not blocked by other signs mounted above, below, alongside, or behind the sign. Other signs shall not be mounted back-to-back with the R1-1 STOP or the R1-2 YIELD signs.

All classifications of signs shall be retroreflective and/or illuminated to show the same shape and color day and night. The MUTCD contain detailed information on signs and sign policies. All persons installing signs should have available, a copy of Part 2 and Part 6 of the MUTCD for ready reference. The Uniform Sign Chart is a listing of some of the more common signs.

A copy of the Uniform Sign Chart should be in every sign truck. The Uniform Sign Chart is available from the Office of Traffic Engineering web site. In addition, the web site has links to traffic sign specification sheets (Caltrans and federal) that contain detailed layouts and dimensions for all signs. Installation details are shown on Standard Plans RS1 to RS4. Typical plans and locations for signs and pavement markings are shown in the MUTCD.

(A) Warning Signs

Warning signs are placed to alert drivers, pedestrians, bicyclists and other road users to road conditions, which may not be reasonably apparent to, and may not have been anticipated by, a person exercising due care and diligence.

Maintenance and/or replacement of warning signs should have top priority over all but a few types of regulatory signs.

Warning signs are generally diamond shaped with black legend and border on a yellow background. Exceptions are the railroad crossing sign (round), the symbolic school crossing sign, changeable message signs, and the rectangular shape used for supplemental signs (such as advisory speed signs) mounted below and on the same post with other warning signs.

Warning signs set up specifically for construction zones shall have a black legend and border on an orange reflective background.

(B) Regulatory Signs

Regulatory signs are used to inform drivers, pedestrians, bicyclists and other road users of regulations that apply at definite Locations, specific times, or where the regulations are not self-evident. This group includes signs regulating the movement, speed, stopping, or parking of vehicles. Regulatory signs are generally black and white or red and white.

The general shape of a regulatory sign is rectangular. The shape of a stop sign is an octagon and a yield sign is an inverted triangle. Two signs for different purposes should not normally be mounted on the same post.

The R5-1 DO NOT ENTER and the R4-1 DO NOT PASS signs are examples of regulatory signs which have high priority for early replacement or maintenance.

(C) Guide Signs

The purpose of guide signs is to provide directional, route, recreational and roadside service information. Guide sign colors are generally green, blue, or brown with white legends and border.

The priority for maintenance or replacement of guide signs depends on the needs of road users in a particular area.

Flashing lights or distracting legends shall not be placed on guide signs.

Unless otherwise approved by District Traffic Operations, a minimum spacing of 200-ft. between guide signs shall be maintained on conventional highways.

A minimum spacing of 800-ft. should be maintained on freeways and expressways.

(D) Colors of Construction and Maintenance Work Zone Signs (i.e., Temporary Traffic Control Signs)

These signs are used to caution motorists in advance of (and through) work zones. The colors for regulatory signs in work zones shall follow the standards for regulatory signs in Table 2A-4 and Chapter 2B of the MUTCD. Warning signs in work zones shall have black legend and border on an orange background, except the W10-1 Rail Road Crossing sign shall have a yellow background. If additional temporary guide signs are used in work zones, they shall have black legend and border on an orange background. The contractor should remove all temporary traffic control signs at the end of a project. In maintenance work zones, Maintenance crews should remove all temporary traffic control signs when the work is complete.

All work zone signs shall be retroreflective when used during the hours of darkness.

Fluorescent orange or orange colors may be used in work zones for temporary warning signs and temporary guide signs. Retroreflective fluorescent orange or retroreflective orange signs may be used day or night. Fluorescent orange signs or orange signs that are not retroreflective shall only be used during daylight hours. Fluorescent orange is a color and is not a substitute for retroreflectivity. Fluorescent orange appears brighter than orange in daylight and is more conspicuous during twilight hours. Fluorescent orange appears orange at night. Fluorescent orange and orange should not be mixed in the same work zone. Signs should be all fluorescent orange or all orange in the same work zone.

## **M2.08 Sign Materials**

All new materials used for traffic signs, must be approved by the Traffic Devices New Products Committee.

This committee evaluates products before general use to assure that proposed materials provide adequate performance. In cooperation with the Office of Materials Engineering and Testing Services, the committee also evaluates the service life potential of new products. The Office of Structure Design, Division of Structures, is responsible for structural design of the sign and supporting structure.

Materials used in the manufacture of signs serve three basic functions:

- (A) Sign substrates provide stiffness as well as a suitable surface for background materials such as retroreflective sheeting. Most current sign substrates are a single thickness of aluminum. Other substrates use aluminum sheet for front and back surfaces with a paper core between, forming a "sandwich" type laminated panel. Steel was used as substrate material for many of the older overhead signs. Substrates such as plywood may be used for special applications but are not approved for general use.
- (B) Sign background provides a colored surface, which contrasts with the sign, message (legend) and border allowing road users to clearly read and understand the meaning of the sign message. The background also serves to attract attention of road users. Background colors are coded to explain the primary purpose of the message. Background materials for all warning, regulatory, guide and construction signs are made of retroreflective sheeting.
- (C) Sign legends convey the message while borders outline the message making it more visible to road users. Sign legends and borders are retroreflectorized for most guide, service, and recreational signs. Warning, regulatory and construction signs generally utilize black non-reflectorized, legends and borders.

The following notation is usually stamped on the lower right side of the back of each sign:

1. PROPERTY STATE OF CALIFORNIA,
2. Name of the sign manufacturer,
3. Month and year of fabrication,
4. Type of retroreflective sheeting, and
5. Manufacturer's identification and lot number of retroreflective sheeting.

Signs having graffiti protection are sometimes marked with a 3/8<sup>th</sup>-inch dot. It is a black dot on white border or white dot on black border. The dot is placed on the lower border of the sign before application of the graffiti protection. The application method and exact location of the dot may vary depending on the manufacturer of the sign.

### **M2.09 Storage and Handling of Signs**

Sign materials can be easily damaged by improper storage or careless handling.

It is important that signs and sign supports be protected in storage and transporting as well as during and after installation. The supervisor is responsible for assuring that signs are handled with proper care at all times.

Proper storage techniques prevent damage such as scratching of sign surfaces or warping of wood sign supports. Although proper storage is generally a matter of using common sense, certain types of sign supports and signs may require special storage techniques. Direct inquiries regarding special storage requirements to the Office of Materials Engineering and Testing Services.

Transport and store sign panels in a manner that protects the face from damage. Protect signs by wrapping, tarping, or other methods to ensure that weather and movement during transit do not damage the face. Keep signs dry during transit and ship on pallets, in crates, or tier racks. Place padding and protective materials between signs as appropriate.

Store signs in a dry environment at all times. Do not let signs rest directly on the ground or become wet during storage. Maintain signs in a freestanding position whether stored indoors or outdoors. When stored outdoors, maintain 4-inch minimum spacing between signs. In areas of high heat and humidity, do not store signs in an enclosed non-climate-controlled trailer or container. Store signs indoors if duration of the storage will exceed 30 days.

Laminated panel signs normally have small weep holes in the channel at the bottom edge. This allows moisture that enters the panel from bullet holes and other damage to drain, thereby preserving the sign's structural integrity.

If the panel is stored upside down or if it is reused and installed upside down, the weep holes allow water to enter the panel rather than helping drain accumulated water. Any unneeded holes observed in laminated panel signs should be plugged or sealed to prevent moisture intrusion. Storage of signs in vehicles used by sign crews is of special concern. Rubbing and marring of surfaces of on-board signs is caused by vibration of the vehicle during travel. A sign can be seriously damaged in this manner before it is installed.

Signs carried in a sign repair vehicle should be kept to the minimum number and type's necessary to adequately respond to short-term needs. Do not permit retroreflective sheeting signs to rub against each other or against abrasive parts of the sign repair vehicle.

Proper storage of wood sign supports in Maintenance yards is important. Sign posts stored flat on the ground or on asphalt can be warped beyond use. Care should be taken to support wood posts above ground level. This reduces warping and cracking by allowing air to circulate providing more uniform moisture and temperature conditions around the sign supports. Refer to Section M2-19 for storage of laminated box-beam sign posts.

Treated wood posts must be stored under cover or tarped to prevent chemical runoff from entering drainage systems. Special care is needed in storage and transporting large signs to prevent warping the entire sign structure, marring the sign surface, or bending edges. Large signs should be stored on edge rather than flat. Flat storage can cause warping and entraps moisture, which often damages sign materials. When stored on edge, it is important that the edge of one sign is not bearing directly against the face of an adjacent sign. Sign edges can easily damage retro-reflective sheeting.

### **M2.10 Installation of Signs**

Installation of signs should be a carefully planned activity. Good planning improves efficiency of the installation procedure, minimizes interference with the traveling public, and assures that potential safety problems are considered.

An important part of the planning process for installing signs is determining the location of underground and overhead utilities. Prior to digging, supervisors shall notify utility companies of intended work through Underground Service Alert (USA), as outlined in Chapter 1 of this Manual, Section 1.27. Serious accidents can result if this step is overlooked. Exercise care when digging in landscaped areas to avoid buried water lines.

Current details for the location and position of signs are available in the Standard Plans and in the California MUTCD. These details are periodically updated and field crews should make sure they have the latest plans when maintaining signs.

The desired result of the sign installation process is that signs effectively communicate information to road users. Placement of signs along a highway should be spaced to allow road users time to assimilate the message. Spacing should be determined in "Units of Time" based on the expected approach speed.



The following general rule is good practice:

If possible, signs should be at least 500-ft. apart. A desired minimum spacing for Guide Signs is 800-ft. on freeways and expressways, and 200-ft. on conventional roads. District Traffic Operations should be contacted to resolve questions about location or position of a sign.

Sign installation can be as simple as digging a hole for a small one-post roadside sign, or as complex as mounting large multi-panel signs on overhead sign structures. In either case, use care to avoid damaging the sign while handling. Retroreflective sheeting is easily damaged when pressure is applied to the face of the sign during installation. The sign might look good in daylight, but the damaged section will appear blacked-out at night. In a multiple-post installation, install posts before the large sign is installed. This will reduce possible damage to the signs. Use fixtures that have been specifically designed for sign handling.

Proper installation procedure is important to ensure long-term service life. Position post holes correctly. The bottom of holes for wood posts should be wetted, tamped, and leveled before posts are installed. In all cases, signs should be level and posts should be plumb.

Safe work practices, including wearing gloves and hard hats, safety glasses and other equipment as necessary to avoid injury to sign crew members. Supervisors should regularly review the appropriate Maintenance Codes of Safe Operating Practices with their crews.

Different sign support systems require different hardware and installation procedures. Hardware is approved for use based on testing procedures designed to assure maximum safety for the motorist. Maintenance personnel shall not use alternate hardware without prior approval of the Division of Maintenance.

Large ground-mounted signs cost several thousand dollars each. Preventable sign damage is an unnecessary drain on Maintenance resources.

Districts should take action as follows to reduce preventable sign damage to the greatest extent possible:

- (A) Identify large signs that may be subject to damage from careless drivers. Damage usually occurs when the lower left corners of these signs are hit by large, slow moving vehicles.
- (B) If feasible and economical, districts should consider relocating such signs during scheduled maintenance replacement work.

- (C) When relocation is not feasible, a guide marker (delineator post) may be installed in alignment with and in advance of the sign in a position that may keep vehicles from hitting the sign. These markers should be retroreflectorized only where such installation will not diminish the effectiveness of existing roadside guide markers (to the extent of confusing the motorist).
- (D) Any measures taken to prevent damage to ground-mounted signs must be consistent with the policy of providing a safe roadside environment. District Traffic Operations should be contacted for approval of any unusual measures that may be necessary to protect signs from vehicular damage.
- (E) When replacing either damaged guide or regulatory signs, consider relocating these signs where they will be less susceptible to damage. This may mean that some signs will be located in less than the ideal position. Written authorization must be obtained from District Traffic Operations before any significant relocation of a sign.
- (F) Landscape irrigation systems are another source of sign damage. Water spots, streaking, loss of retroreflectivity and corrosion can result from sprinkler heads directing water onto the sign panels. In addition to damage to the sign panels, wood sign posts (especially laminated wood sign posts) can be severely damaged by repetitive spraying from landscape sprinkler systems.

Damage can be eliminated or reduced by making minor field adjustments to the sprinkler system to avoid spraying adjacent sign panels and wood posts. It may be necessary to move the signs to another location.

- (G) Nonstandard installations may be justified where special circumstances exist.
  - (1) Damage to signs can be reduced in heavy snow removal areas by modifying normal installation procedures. Laminated panels may be offset so the overhang on the roadside edge is reduced. In addition, laminated panel signs should be ordered in the 2-½ inch thickness to provide the stiffness necessary to resist snow loads. This has proven effective in reducing the number of signs damaged during snow removal activities.
  - (2) Upon request, District Traffic Operations can reduce the size of a sign by "stacking the message" thereby reducing the surface area exposed to the elements.
  - (3) Single sheet warning and regulatory signs, may be reinforced, by backing the new sign, with a salvaged aluminum blank. The new sign can be riveted to the salvaged sign to obtain greater stiffness.

- (4) One-post directional signs for installation within sidewalk areas of cities and towns should generally be ordered for off-center installation. The post, located at the left-hand edge of the sign face, may then be placed near the curb where it will not interfere with pedestrian traffic.
- (5) Two-post signs are more difficult to install in sidewalk areas. When necessary, one post should be placed at or near the curb line with the second post at or near the property line. The sign may then be mounted on 2" x 4" lumber placed horizontally between the posts. Property owners have objected to this type of installation, and it should only be used when a sign is too long for one-post mounting.

### **M2.11 Sign Maintenance**

No definite rule has been established to determine when a sign is damaged beyond repair or when a sign should be repaired and retained in service. In general, a sign should be replaced if it cannot economically be repaired to present a neat appearance. Sign Maintenance personnel should rely on experience. Historical data and best judgment to arrive at cost-effective decisions regarding sign maintenance.

Washing or cleaning signs is a proper sign maintenance activity, but only if it is cost-effective.

In certain situations, the better alternative may be to replace rather than wash or clean a sign.

Special Programs People may be used to make washing signs a cost-effective alternative to replacement.

Specific methods and materials are recommended for repairing different types of signs.

Questions regarding materials used for repairing and cleaning signs should be directed to the Office of Materials Engineering and Testing Services. This is especially important with regard to retroreflective sheeting signs because the sheeting surface is easily damaged by use of improper cleaning agents. Questions regarding specific methods of sign installation or maintenance may be directed to the Division of Maintenance.

The variety of tasks involved in the maintenance of signs means that districts must exercise judgment to arrive at cost-effective choices in terms of how best to utilize available Maintenance resources. Ultimately, the districts are responsible for making proper, cost-effective decisions regarding sign maintenance.

### **M2.12 Hidden Signs**

Landscape plantings maturing along many miles of highways have increased the number of signs that are obscured. Signs hidden by natural vegetation or designed landscaping are of no benefit to the motorist. Corrective alternatives should be considered in the following order when signs are hidden:

- (A) Is the sign necessary? (Check with Traffic for guidance).
- (B) Can the sign be economically moved to a better location?
- (C) Is it feasible to trim vegetation to the extent that the sign can be seen?
- (D) If periodic trimming has been necessary, would removal of the tree or other vegetation be a better alternative?

Occasionally, signs may be hidden by other signs, or sight restrictions, such as cut slopes or buildings. Notify the District Traffic Operations unit when this occurs for direction regarding appropriate corrective action.

### **M2.13 Obsolete Signs**

Periodically, some signs are eliminated, or changes are made in messages, designs, sizes, or colors. The result is that existing signs become obsolete, even though they may adequately serve the intended purpose for many years. Unless otherwise directed by Traffic Operations, such signs should remain in service until normal maintenance replacement is required. Directed replacement of signs before the end of normal service life is considered "betterment", and such costs must be from capital improvement funds.

Obsolete signs in inventory that have not yet been installed should be returned to a Material Operations warehouse for disposal.

Due to the adoption of the California MUTCD, a number of signs have been designated as obsolete, and target dates to remove and replace these signs have been established by Traffic Operations. Please refer to Figure I-101 entitled California Signs With Target Compliance Dates for current listing of obsolete signs in 01/06/05 TCD Target Dates to CTCDC at: <http://www.dot.ca.gov/hq/traffops/signtech/signdel/policy.htm> for a full listing of these signs. Direct all questions about these signs to District Traffic Operations. Speedometer check signs are being phased out. When a speedometer check sign in a series of speedometer check signs is damaged, that sign and all others in that series should be removed, eliminating the installation.

### **M2.14 Temporary Signs**

Temporary signs shall be maintained only as long as the need for that sign exists. When the need no longer exists, temporary signs shall be removed or covered completely. It is not acceptable practice to cover the sign message only.

Temporary signs shall have a retroreflectorized background and/or legend and border depending on the standards for that particular sign. Temporary signs shall also conform to the color, size, material, and other requirements, which apply to permanent signs of that type, unless otherwise specifically authorized in writing by District Traffic Operations. Depending on the type of sign and expected usage, the service life of temporary sign materials may be somewhat less than that used for permanent signs.

Districts shall keep an adequate inventory of materials available for immediate fabrication of emergency signs.

### **M2.15 General Sign Support Information**

Types and sizes of ground-mounted sign supports should be initially chosen on the basis of:

- (A) Safety in the event of a hit by an errant vehicle.
- (B) Ability to withstand a "blow down" in heavy wind, depending on the size of the sign.
- (C) Cost analysis considering both the initial cost of the support and the ongoing, future cost of maintenance.
- (D) Aesthetics or compatibility with surrounding features.

Current Statutes prevent the use of Maintenance funds for upgrading posts (bringing existing posts to current standards). However, districts have the option of reviewing each sign location using future maintenance costs as a criterion for recommending a change in type of sign support.

With proper documentation and concurrence of District Traffic Operations, the type of support can be changed to provide a more cost-effective installation when replacement is warranted. Safety of the public shall always be included in such a review.

Holes shall not be drilled in light standards for the purpose of installing signs. Signs at these locations shall be banded to the post using standard hardware designed for this purpose.

Hidden depressions resulting from post removal present a hazard to workers and should never be left unfilled when installations are abandoned. Make contractors and permit holders aware of the problem.

### **M2.16 Wood Posts**

Dimensioned wood posts have long history of success as sign supports for smaller ground-mounted signs. Wood posts may still be the most cost-effective installation, especially in locations where it is unlikely they can be hit (e.g., behind guardrail). Unless conditions otherwise dictate, the wood post is the primary sign support structure used.

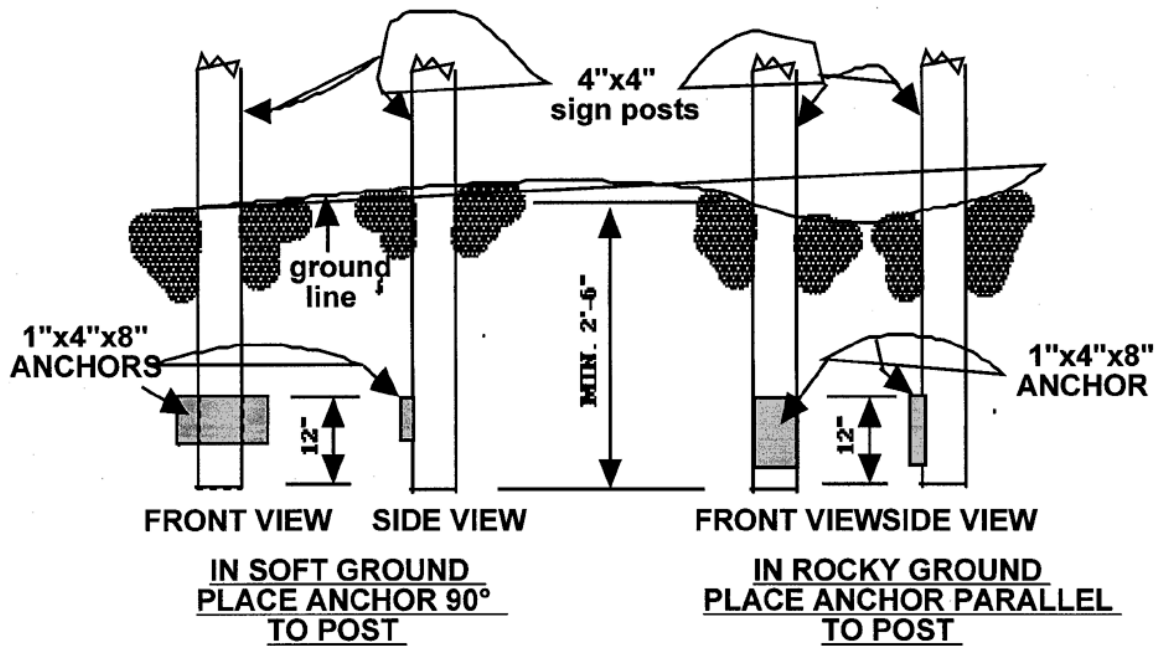
Where needed, holes are to be drilled in the larger wood posts to provide a weakened plane for breakage when the post is impacted by a vehicle. It is important to make sure the holes are drilled at the specified height above the ground. The holes are placed at this height so the broken end protruding above the ground will not snag the bottom of a car. See current Standard Plan sheets for details on hole locations.

Anchor blocks may be used on wood posts where signs are located in soft ground, near schools, and at locations frequently used by pedestrians. The anchor blocks prevent the sign from being rotated in the hole, lifted out, or stolen.

Wood sign posts shall not be painted.

When handling treated wood posts, skin contact shall be avoided. Wear long sleeved shirt and gloves and avoid breathing wood dust when sawing or drilling posts.

**ANCHOR BLOCKS FOR WOOD SIGN POSTS**



**M2.17 Steel Posts-Small Signs**

Several patented breakaway metal post systems for small signs have been approved for operational use. The use of breakaway metal post systems has both advantages and disadvantages.

(A) Advantages of breakaway metal post systems:

- (1) Relative ease of installation (no need to dig a hole).
- (2) Possible reuse of the base post after vehicular impact, with resultant long-term cost savings.
- (3) Improvement in motorist safety provided by the breakaway feature.

(B) Disadvantages of metal post systems are:

- (1) Posts are not interchangeable. Once a base post is placed, there is no economically feasible alternative except to purchase replacement posts of the same design.
  - (2) A variety of driving heads, bolts, and other materials must be carried in the sign truck to permit repairs or modifications to different installations.
  - (3) Underground utilities may be damaged when driving the post.
  - (4) Different methods of attaching signs to posts may require strengthening of some sign panels to prevent excessive bending and distortion of the sign message.
- (C) Special installations where the breakaway metal sign post system can be an acceptable alternative to wood posts, based on life-cycle cost, are:
- (1) Areas with a high incidence of hits.
  - (2) Locations where wood posts are vandalized.
  - (3) Where driving a post is easier than digging a post-hole (in granular, loose, or rocky soil).
  - (4) Where the post is required to blend with the surrounding environment.

Decisions to use steel sign supports for replacement purposes will be the responsibility of the district, and should be based on consideration of the above factors. Warehousing of all types of breakaway metal sign post systems is not anticipated at this time. Some orders may have to be placed through local distributors. Orders for a particular type of post must be justified.

### **M2.18 Timber Poles**

Installation of new or replacement timber poles (non-dimensional lumber) is no longer acceptable when sign supports with yielding or breakaway characteristics are required. Timber poles may continue to be used where the sign location is protected or where the sign is not readily accessible to traffic.

Protected locations include those behind guardrail, bridge railing, or similar barriers; or on cut slopes where the sign posts are located four (4) feet or more vertically above the edge of paved shoulder.



When timber poles are used behind barriers, the barriers must be required for purposes other than just to protect the sign. Drilling of holes and sawing of weakened plane breakaway joints will not be required at these locations.

Timber poles in existing locations may remain in place until damaged or otherwise directed to be removed by District Traffic Operations. Acceptable alternates for timber poles are the laminated box beam and breakaway steel supports for large signs. Combinations of timber poles and alternate sign supports will not be permitted in the same multi-post installation.

### **M2.19 Laminated Wood Posts**

Breakaway holes must be placed at the proper height above ground to prevent the remaining stub from snagging the bottom of an impacting vehicle. See current Standard Plan sheets for hole locations.

A laminated wood post (high-grade plywood in appearance) has been approved for installation of large signs in areas exposed to traffic, where timber poles were formerly the standard.

Laminated posts are designed to meet federal requirements for change in momentum during an impact by breaking cleanly when impacted by a lightweight vehicle traveling at 20 mph..

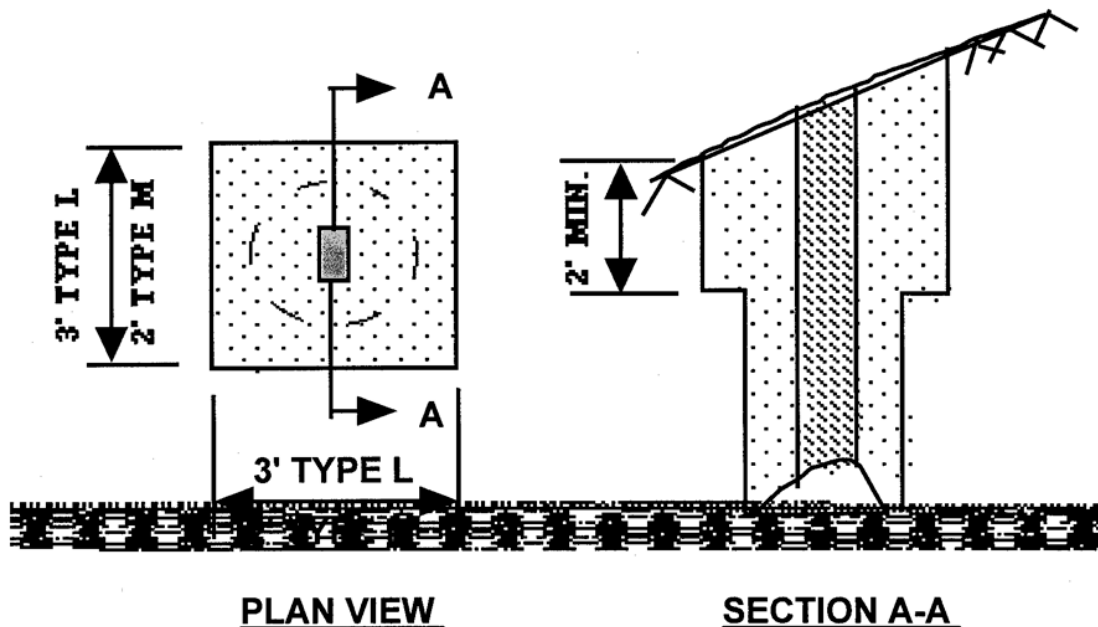
Laminated posts are relatively fragile and must be stored and handled carefully. Techniques for storing laminated box-beam sign posts require a minimum 6 inch clearance at the base of the pile, in addition to stickers placed between each layer of posts. Posts should be stacked on edge, and the top of the pile should be covered with a layer of plastic or tarp to prevent rain from damaging the posts.

Some of the newer laminated wood posts are coated with special waterproofing material to minimize cracking and warping and give a longer service life. Re-coating of these posts may be beneficial in the future if field inspections indicate that the coating film is breaking down.

To ensure that laminated wood sign posts will break away properly when hit and still not be damaged by high winds, it is important that posts be installed in holes as specified and back-filled with a granular material. The relationship of hole size and soil condition is critical in assuring that there is a proper breaking away of the upper portion of laminated wood box beam posts when hit. The bottom must be held firmly in place to allow a clean break of the post at ground level. Soft or yielding ground will permit movement of the entire post and the desired type of breaking will not be accomplished.

Two alternative post-hole configurations have been approved for use:

- (A) If the ground is very firm, similar to compacted highway fill, the hole diameter may be reduced six inches in diameter. For these conditions the permissive size of hole is 18 inches for the type "M" post and 24 inches for the type "L" post.
- (B) If the foundation material surrounding the post is not firm when in a saturated condition, the 18 inch and 24 inch diameter holes mentioned above may be used only if the upper portion of the hole is modified to provide satisfactory lateral support. This modification is to be accomplished by removing at least 2 ft. of the upper portion of the existing soil to the dimensions shown below, and replacing with a granular backfill material.



### M2.20 Breakaway Steel Posts for Use With Large Signs

The wide flange breakaway steel sign post, which meets the federal requirements for change in momentum during vehicular impact, has been available for many years. Carefully follow plans that cover standard installations. Correct alignment of post sections and placement of bolts in the slip base is critical to proper functioning of the breakaway feature.

A major disadvantage of the steel breakaway post is the need to fabricate a new post every time an existing post is hit. This requires field measurement of the exact length required for replacement. Some time lag is inevitable before the steel post can be replaced.

### **M2.21 Overhead Steel Sign Supports**

Overhead steel sign supports are designed by the Division of Engineering Services. Repairs should be performed by contract unless the district has workers proficient in structural steelwork and painting.

### **M2.22 Hardware**

All signs shall be affixed to posts with galvanized hardware. Fiber or nylon washers shall be used to protect the face of the sign. Placing a metal washer between the fiber/nylon washer and the bolt head is recommended to provide more bearing and reduce rocking of the sign on the post. Use 5/16 inch x 7/8 inch washers for 1/4 inch bolts and 3/8 inch x 7/8 inch washers for 5/16 inch bolts. An additional washer placed between the nut and the post will prevent the nut from digging into the post during tightening.

The threads near the ends of bolts protruding from sign posts may be "upset" or deformed to prevent the nut from being removed by vandals. Districts may also purchase commercially available "anti-theft" hardware for use in areas subject to vandalism and theft.

Large signs placed on laminated box beam sign posts must be installed using 1/2 inch lag screws for attaching sign panels to the post. Lag screw pilot holes drilled in wood flanges for attaching sign panels must be 5/16 inches in diameter so that the panels will not blow down in heavy winds.

Bolting completely through the post is not acceptable practice because the sign panel will not readily release from the support post during impact.

Overlay plates for making changes to existing signs (not made from steel) shall be attached using aluminum rivets. Stainless steel rivets shall be used on the older porcelain on steel signs.

Galvanized back braces should be used for installation of all large single sheet signs placed on one post. A special back brace is available for one-post directional signs installed "off-center."

One-post installations of signs (with a height of 18 inches or more) require a small wood block between the center of the sign and the post to stiffen the sign and prevent "flutter" under some wind conditions. This block also causes the sign face to distort slightly, which reduces glare.

For details, see Standard Plan RS2. Do not use a block more than one (1) inch thick, as distortion will make the sign ineffective for night retroreflectivity.

**M2.23 Supplemental information**

District Traffic Operations can provide current standards for each sign truck. Supervisors are responsible for assuring that the current drawings and standards are available for performance of work.

Upgrading (improving) existing installations to meet current standards is not normally funded from Maintenance allocations. Exceptions may occur where formerly used materials are no longer available, or where new materials can be expected to provide a longer service life, thereby reducing future maintenance costs.

These exceptions are normally justified at the Headquarters level, and instructions are transmitted to the districts for implementation.

Sign crews should retain copies of old Standard Plans and other reference documents for maintaining existing installations. The intent of this instruction is to eliminate "upgrading" of existing installations using funds dedicated for maintenance purposes in conformance with the law.

## **Section 3 – Safety Devices (Family Problems M6, M7, M8, & M9)**

### **M3.00 Introduction**

Safety devices are provided and maintained for the protection and guidance of traffic.

This section includes work in the following Family/Problem areas:

- M5 Roadside Delineator Post
- M6 Guardrail
- M7 Median Barrier
- M8 Vehicle Energy Attenuators (energy dissipaters)
- M9 Out of Control Vehicle Ramps (portion)

Unsatisfactory performance or problems with maintenance of traffic safety devices should be reported to the Division of Maintenance.

Refer to Maintenance Manual Volume 2, for planning, scheduling and administrative procedures connected with the “M” Family.

The following section (M3.01) discusses maintenance levels applicable to work in the “M” Family. Sections M3.02 and M3.03 describe the proper use and general guidelines for the various devices, and discuss installation and maintenance details and checklists.

### **M3.01 Levels of Maintenance**

The proper maintenance of traffic safety devices is important in providing maximum protection to the traveling public and for general appearance of the roadside. Levels of Maintenance, including frequency and priority of action for severe damage (any damage that can affect the ability of the safety device from performing its intended function) are included in Maintenance Manual Volume 2 for budgeting purposes. Levels may vary depending on overall appropriation of funds by the Legislature.

**M3.01.1      Guardrail**

Guardrail should be routinely observed for deficiencies. It should be maintained approximately true to line, grade, and functional height. Timely adjustments should be made to correct guardrail height when the original installation is degraded by the buildup of pavement or shoulder material, shoulder erosion, fill settlement, or any other cause. Missing anchor cables must be replaced. End treatments should be maintained according to the current Standard Plans.

Damaged rails and bent or missing delineators should be temporarily repaired if an obvious hazard exists or if functional integrity is impaired.

Permanent repair or replacement should be scheduled according to the priorities set in the Maintenance Manual Volume 2. Any remaining adjustments to line and grade should be done, when conditions permit, in conjunction with other repair work.

Rail that has previously been painted for delineation should be washed or repainted as needed.

Washing and painting of unpainted rail is not required. End caps on the downstream ends of guardrail adjacent to one way roadways should not be replaced when damaged.

**M3.01.2      Median Barriers**

For removable panels of glare screen that are missing, or damaged, contact the District Traffic Safety Device Coordinator for recommendation regarding if it should be maintained or replaced.

**(A)    Thrie and Metal Beam Barrier**

- (1)    Surveillance should be made for structural integrity, height, and alignment.
- (2)    Repairs should be made promptly if a traffic hazard exists or functional integrity is questionable. Damage not constituting a hazard to traffic or functional integrity should be repaired when the schedule permits.

**(B)    Cable Barrier**

- (1)    The effectiveness of cable barrier is extremely sensitive to the height of the cable.  
  
Make periodic surveillance for structural integrity, height, and alignment.
- (2)    When damaged, temporary repairs should be made promptly by propping up the cable to the height of the adjacent cable and cutting off posts that may be considered an obstacle to traffic.

- (3) Damaged posts should be scheduled for replacement at the earliest practical time.

Posts replaced in sleeves in the foundation may be back filled with concrete sand in lieu of paving asphalt.

- (4) Permanent repairs should be scheduled promptly. Surface irregularities such as berms or windrows resulting from shoulder grading must not be allowed adjacent to cable barriers.
- (5) Reflectors on cable median barrier will not be maintained when the median edge is delineated by striping and/or raised pavement markers.
- (6) Questions concerning the maintenance of cable median barrier not covered here should be referred to the Division of Traffic Operations Liaison.

(C) Concrete Barrier

- (1) Concrete median barriers generally require little maintenance. Surveillance is necessary to ensure prompt repair when the barrier is broken or pre-cast units are toppled over or knocked out of line.
- (2) Concrete barriers are not to be painted to eliminate tire marks.
- (3) Retroreflective delineators, placed as part of the original installation or retrofitted to meet special needs, should be maintained with the reflectors clear of material that obscures them. Missing or damaged retroreflective delineators should be replaced promptly.

M3.01.3 Crash Cushions

Crash cushions, also known as impact energy attenuators, are intended to protect the motorist from the consequences of collision with a fixed object. Routine surveillance should be performed to ensure that these devices remain functional. Detailed inspections should be made to ensure that the components are in satisfactory condition.

Damage that impairs the functional integrity of attenuators should be repaired as soon as possible. Less critical damage may be repaired in conjunction with other maintenance operations.

Debris should be periodically removed from under or around attenuators. The accumulation of large amounts of debris can hinder sliding action and impair the functioning of these devices and presents an unsightly appearance.

**M3.01.4      Roadside Delineation Posts**

Roadside delineation posts should be maintained in an upright position, facing traffic and with reflectors clear of material that obscures them. Any markers or reflectors that are damaged or missing should be replaced to meet current standards. Post mile information (Rte-Co-P.M.) shall not be placed on markers that are not part of the post mile system. Flexible posts are the standard, however metal posts may be used as needed to accommodate driving posts in hard or rocky soil.

**M3.01.5      Damage Guidelines for Safety Barriers**

Severe damage as a result of an impact to a safety barrier (guardrail, median barrier, or crash cushion) is defined as any damage that significantly alters the structural integrity of a barrier and could alter the performance of a barrier during a subsequent impact. Examples of severe damage may be:

- Posts (for MBGR, Thrie Beam, or MBMB) are broken or out of alignment with original position by more than 12 inches horizontally.
- Metal sections (MBGR, MBMB, and Thrie) are out of alignment with original installation by more than 12 inches horizontally.
- Bolts are missing or have torn through metal sections.
- Metal sections have been split or torn.
- Sections of concrete have been loosened or knocked out of the barrier.
- Cable supports have been knocked down, or the cable is lying on the ground.
- Any end treatment or crash cushions damage.

There may be other examples of severe damage not listed here.

Damage that is not considered severe damage is damage that does not significantly degrade or alter the structural integrity of the barrier and is referred to as minor damage. Rubs and scrapes that do not push a metal barrier out of alignment more than 6 inches, and aesthetic damage such as tire marks are examples of minor damage.

**When a question arises on a specific location as to the extent of the damage and the impact on structural integrity, or the ability of the device to perform as intended, contact the District Traffic Safety Devices Coordinator in District Traffic Operations to have the location evaluated by an engineer.**



### **M3.02 Uses and General Guidelines**

#### **M3.02.1 Guardrail**

Guardrail is a safety barrier installed on State highways to reduce the combined effect of severity and frequency of "runoff the road" type crashes. This is accomplished by redirecting a vehicle away from embankment slopes or fixed objects and dissipating the energy of the errant vehicle. The W-beam channel is the most common barrier used for guardrail applications and is commonly known as metal beam guardrail (MBGR), though concrete and other types of barrier may be used. Guardrail sections also include the end treatments and transitions that are attached.

Existing guardrail is to be maintained in accordance with the Department of Transportation Standard Plans. Any deviation to install, delete, or modify must be by prior approval of District Traffic Operations.

The approach ends of most guardrail end treatments are usually turned away from approaching traffic to minimize the probability of an end on collision, depending on the end treatment used. Both ends of guardrail installations are anchored to prevent failure of short sections of guardrail and minimize "pocketing" during a collision.

End caps are no longer installed on the trailing end of guardrail adjacent to one way roadways and are not to be maintained. Existing curved end sections on the trailing end of one way roadway guardrail may be salvaged for use as needed.

Damaged breakaway terminals must be replaced with acceptable current standard breakaway terminals as approved by the Division of Traffic Operations.

Variable heights of guardrails are readily apparent to motorists, as well as being a potential safety problem and priority should be given to maintaining them to proper levels. Persons responsible for project reviews, construction and maintenance inspections should be alert to the potential need to adjust rail height because of pavement overlays.

Restoration of any damaged breakaway guardrail terminal is to be made by installing the current standard breakaway terminal as shown in the latest edition of the Standard Plans. Contact the District Traffic Safety Device Coordinators, Headquarters Division of Maintenance, or Headquarters Traffic Operations Liaisons for more information.

- (A) The following guidelines should be used when replacing damaged guardrail:
  - (1) Metal plate (Tuthill) guardrail is no longer appropriate for use on the State highway system. Damaged sections shall be replaced with standard guardrail.

- (2) In all cases when nonstandard guardrail is damaged to the extent that a section or sections must be replaced, District Maintenance will immediately advise District Traffic Operations, and corrective work will be initiated based upon their recommendations. Mixtures of old and new types of guardrail in a run should be avoided.
  - (3) When upgrading guardrail, current standards will apply as to post size and spacing, rail elements, anchorage and positioning. District Traffic Operations personnel will furnish Maintenance forces with the necessary guardrail design information.
- (B) Charges for replacement upgrading of damaged guardrail will be apportioned as follows:
- (1) The cost of "replacement in kind" of the damaged guardrail to be shown on the damage report should be an estimate based on the district's prior charges for similar work.
  - (2) Capital outlay costs (upgrading) will be the actual cost of replacement to current standards, less the amount for "replacement in kind" shown on the damage report.
  - (3) When any upgrading by Maintenance forces is involved in a replacement of damaged guardrail, a specific work order is required incorporating the split-funding provisions. Most districts have blanket type improvement E-FIS Project Code to fund this type of work. When possible, upgrading of guardrail should be accomplished by contract.
  - (4)

### M3.02.2 Median Barriers

Median barrier is a continuous safety barrier placed in medians of divided highways to prevent an errant vehicle from crossing the median and colliding with opposing traffic. Although not part of the initial design, it may also prevent the deflection of a vehicle colliding with the barrier back into traffic stream, and decelerate the errant vehicle within tolerable limits. Concrete Type 60 and metal Thrie beam are the most common types of median barriers. Cable systems and W-beam (looks like guardrail, but referred to as metal beam median barrier MBMB) have also been used in median barriers.

See California Standard Plans for flares and special conditions covering median barrier installations.

(A) Thrie Beam Barrier

Thrie beam barrier is a type of metal beam barrier that has rail elements containing 3 ribs that are 20 inches high. There is no channel rail. The top of the rail is 32 inches above the ground.

(B) Metal Beam Barrier

The top of metal beam median barrier is 30 inches above the ground beneath the rail.

The top of the posts are level with the top of the rail element. The blocks extend approximately 1 inch above the top of the posts and rail elements.

(C) Cable Barrier

Emergency openings in cable barrier must be secured after use. Failure to do so reduces the effectiveness of a substantial length of cable barrier.

Research indicates that consolidated sand is a satisfactory filler material in lieu of asphalt for use in cable barrier post footing sockets. As a result, dry, clean, commercial quality concrete sand may be used as an alternative filler material in "Type B" cable barrier footings. The sand should be consolidated and compacted in the post socket by a minimum of 25 hammer blows to each side of the post.

Questions concerning the maintenance of cable barrier should be referred to the Division of Traffic Operations Liaison.

(D) Concrete Barrier

The top of Type 50, concrete median barrier is 32 inches above finished grade. Present design of the barrier does not call for a below ground footing except at ends or joints in the barrier. The Standard Plans indicate the location and amount of steel reinforcement in the barrier. The Type 60 single slope concrete median barrier is the current standard and is being installed throughout the State.

The standard height for the Type 60 barrier is 36 inches, although 32 inch and 56-inch tall barriers may be installed as field conditions dictate. Check the latest Standard Plans for complete details and clarification.

M3.02.3      Crash Cushions

Crash cushions, also known as impact energy attenuators, are intended to reduce the severity of a collision with a fixed object that cannot be removed or protected by other types of protective systems.

Cushions/attenuators are expensive to install and maintain. Special problems or unsatisfactory performance should be immediately brought to the attention of District Traffic Operations.

Type R chevron markers should be installed on the front of the attenuators whenever traffic may proceed on either side of the installation. The point of the chevron should be at the top of the marker.

(A) Collapsible Units

Present designs of water filled plastic tube, and lightweight crushable canister attenuators use overlapping fender panels along the sides of the assembly. These systems are held in position by anchor cables and use a backup structure.

Successful operation of sliding type units depends to a large extent on keeping the area free from objects and debris that can resist movement of the units. Care must be taken in machine sweeping to assure that there is no excessive buildup of debris within the device.

(B) Sand Filled Units

Sand filled plastic barrels are free standing and approximately 3 ft. in diameter by 3 ft. These barrels contain specific weights of sand depending upon their location in the installation. Sand filled barrels may "walk" or move downhill when installed on a slope. When this occurs, a stop or restraint is needed for each barrel.

Location of the barrel in the array and weight of sand in the barrel are critical in determining how the unit functions when impacted.

Whenever possible, location and weight of the barrels should be painted on the pavement to facilitate replacement. If this is not possible (e.g., installations in unpaved areas), weights can be marked on a marker Post Plate.

Copies of "As Built" plans can also be used to supply the information. Marking the weight on the sides of barrels or on the lids is unsatisfactory since these notations are lost in most impacts. Contact District Traffic Operations when no other information is available.

Sand used in filling barrels must be capable of remaining in a loose condition throughout the expected life of the barrel. Sand that contains clay particles, or is not well graded, is capable of exerting excessive stresses during expansion/contraction of the barrels, and can cause premature failure of the unit. Cohesive materials can also result in failure of the array to dissipate energy when impacted by a vehicle.

Until further modified by the Engineering Service Center, Office of Materials Engineering and Testing Service, the following recommendations should be followed in filling barrels :

1. The sand used to fill modules shall be a clean washed concrete sand of commercial quality conforming to the sieve analysis requirements of ASTM C33- with no more than 1 percent of the sand passing the No. 200 sieve. The sand must not contain clay lumps.
2. Bagged sand shall not be used. At the time of placing in the modules, the sand shall not contain more than 7 percent water, as determined by Test Method No. Calif. 226.
3. Laboratory tests have shown that sand filled crash cushions will function correctly when "Energite", "TraFFix" and "Fitch" sand barrels are mixed, as long as the array position and sand weight are maintained.
4. Lids should be fastened to the sand barrel shell consistent with the manufacturer recommendations. This is to minimize the scattering of debris during an impact. Some sand barrel lids have traveled a considerable distance. The placement of 4 pop-rivets, spaced equal distance, around the barrel are satisfactory.

#### M3.02.4 Roadside Markers

Roadside markers comprise the various permanent devices, excluding signs, used off the traveled way to guide the motorist and warn of restricted width and/or identify or mark locations along the highway. Instructions for use of roadside delineators, object markers, and channelizers are included in Part 3 of the California MUTCD.

- (A) Flexible delineators will generally be used for maintenance replacements unless the following conditions are met:
  - (1) Where it is necessary to attach snow poles to posts.

- (2) In rocky areas or hard ground where steel posts have some advantage in driving.

Consideration may be given to the possibility for using a two part, metal base and flexible post system in these areas.

- (3) In protected areas where posts are not exposed to traffic (such as behind guardrails and in front of structures).
- (4) When there is a need to support post mile markers.

Decisions regarding locations on existing roads which warrant the use of flexible delineator posts shall be the responsibility of District Maintenance in consultation with District Traffic Operations. Circumstances of weather, snow removal, difficulty of installation or other special needs will dictate when metal markers are required.

Any widespread district program to upgrade undamaged installations to provide uniformity of appearance is considered "improvement work" and cannot be done using Maintenance funds.

Replacement and salvage of guide markers in good condition is not generally cost effective. An exception may be considered where, after knocked down markers have been replaced, the remaining metal guide markers in good condition on a particular ramp or curve represent 25 percent or less of the total number of delineator posts. In this case, replacement of the remaining metal markers for the sake of uniform delineation treatment may be considered.

Excess markers are a needless expense to install and maintain and should be avoided whenever possible. However, except for culvert markers and clean out markers used by Maintenance, all markers on the system should be maintained unless directed otherwise by the District Traffic Operations.

(B) Delineators

Attention is directed to Standard Plan A73C and Figures 3D-101 through 3D-105 of the CA Supplement. The purpose of delineators is to indicate the roadway alignment and to accent critical locations. Delineators should not be used for other purposes. The practice of using them to mark drainage structures, pull boxes, underground utilities, etc. should be discontinued.

All delineators shall be retroreflectorized. Retroreflective sheeting shall have a minimum dimension of 3 inches in width and 12 inches in height.

Uniformity of type, color, and positioning of reflectors to delineate the roadway is essential. All proposed deviations from the patterns shown in the California MUTCD should be cleared by District Traffic Operations.

The overall line of delineators should parallel the roadway centerline as closely as possible. When possible, delineators should be placed 2- ft. outside the edge of the usable shoulder but not more than 12-ft. from the pavement edge. In curbed sections, the markers will be placed 2- ft. outside the face of the curb.

**(C) Clearance Markers**

Attention is directed to Standard Plan A73B and Figure 3C-101 of the CA Supplement. Clearance markers are used to indicate obstructions or restrictions in width to the right of traffic, including bridge and culvert rails. They should be placed for all major obstructions in the plane of the roadway and within 4-ft. of the edge of shoulder. On divided highways, clearance markers are also used to the left of traffic for the same purpose. All clearance markers are retroreflectorized for night visibility.

Clearance marker posts are placed on a line with the edge of the obstruction nearest to the pavement. When placed in conjunction with guardrail on bridge approaches, the clearance markers are located immediately behind the guardrail and at sufficient height to make all reflectors visible to approaching traffic.

**(D) Culvert Markers**

Attention is directed to Chapter 3D of the CA Supplement in section entitled “Culvert Markers.” Culvert markers are placed as a convenience to Maintenance crews in marking locations of culvert openings. Such marking is sometimes necessary to protect culvert ends from damage from adjacent operations as well as to serve as an aid in locating culverts during storm conditions.

Most culverts can be located without the use of markers and in such cases, and if protection is not needed, markers need not be used. When culverts are difficult to locate, markers may be placed on each side of the roadbed, above the culvert. They may be placed either outside or in line with a series of markers.

Culvert markers should not be retroreflectorized except where the marker is well off the traveled way and locating the culvert could be a problem during hours of darkness. The possibility that the culvert marker might be mistaken for a road delineator should be avoided.

Culvert markers are not part of the post mile system for identifying locations and post mile markings (Rte.-Co.-P.M.) are not to be stenciled on replacement culvert markers. If needed for Maintenance identification of a particular culvert, crews should stencil only the numerical value of the post mile (not route and county) on new or replacement markers.

Removal of excess culvert markers may be done at any time as part of routine Maintenance operations. Revision of existing markers to eliminate retroreflectorization and post mile markings, should be performed whenever the marker requires replacement for other purposes.

(E) Emergency Crossover Markers

Attention is directed to Chapter 3D of the CA Supplement in section entitled "Emergency Passageway Marker." Markings for abandoned or obliterated crossovers should be removed.

Use of fencing and or gates at crossover locations to prevent unauthorized use is strongly discouraged, except in the most unusual circumstances. Acceptable locations for the establishment of gated crossovers would be for use for incident management detours or snow removal operations.

(F) Post Mile Markers

Attention is directed to Standard Plan A73B for Highway Post Marker. The post mile marker is an integral part of the post mile system, and is used by traffic officers, Maintenance personnel, and others to locate specific incidents or features on the roadway with respect to the post mile system. Post mile markers should not be used for additional marker functions, and other type markers should not be used as post mile markers. The post mile marker shall indicate the route, county, and post mile of the installation; only post mile markers shall contain the route and county designation.

The lettering size shall be 2½ inch letters for county, route and post mile fraction (hundredths). The post mile numerals shall be 4-inches in height.

Post mile markers shall not be retroreflectorized. When installed behind guardrail, the marker should be placed so that the entire legend is readable from the road.

Stenciling of the post mile on concrete median barriers is permissible in addition to, but not in place of, the regular post mile markers located along the outer shoulder. This is an additional aid for Maintenance and accident investigation forces.



District Traffic Operations shall have the responsibility to verify the accuracy of the placement of post mile markers. All post mile markers should be located to an accuracy of 50 ft. (0.01 mile) on the ground. The value shown on the marker shall be to the nearest 0.01 of a mile, and shall reflect the mile point of the centerline opposite the marker location. If any are found to be more than +/- 0.01 mile from the intended location, they must be relocated.

Periodic field review and inspection should be conducted to locate damaged or illegible markers. Reports of incorrect post mile markers may originate from various sources.

The District Traffic Operations and the Roadway Records unit of Headquarters Division of Traffic Operations must be in agreement as to which field markers will be corrected and which accident records will be relocated before any action is initiated. Care must be taken in replacing damaged markers to assure that the new marker is installed in the same place as the old marker.

**(G) Miscellaneous Markers**

Roadside markers are sometimes used to mark the location of pull boxes, survey monuments, water line crossings, etc. Where such items are readily visible or can be found easily, marker posts should not be installed. These markers shall not be retroreflectorized. When placed adjacent to the shoulder, the markers should face approaching traffic.

**M3.03 Installation/Maintenance Details and Checklists**

Installation standards and drawings for traffic safety devices may change as new materials, equipment, and traffic needs are identified. Be sure that the latest information is used for any new installation.

District Traffic Operations will provide current standards for each installation. Supervisors are responsible to assure that current drawings and standards are available for performance of work.

**M3.03.1 Metal Beam Guardrail, Thrie and Metal Beam Median Barriers**

- (A) Check the plans. Know what the design requires.
- (B) The 6-inch side of 6-inch x 8-inch timber posts should be next to the rail.

(C) The posts should be set to the full depth shown on the plans. If this is not possible due to the presence of spread footings or other underground obstruction, some acceptable alternative method of setting the posts securely should be used. The Standard Plans contain some alternatives. Others may be obtained through the Construction Division or District Traffic Operations.

(D) All rail laps should be in the direction of traffic adjacent to the rail.

(E) Splice bolts should be tight with full bearing on the rail and not on bolt shoulders. The recess in the nut should face the bolt shoulder. Otherwise, the splice will not be tight.

Use all the splice bolts the plans call for.

(F) Bolts should be long enough, so that nuts, are threaded completely onto the bolt. A one (1) or two (2) thread connection is not satisfactory. This should be checked, especially at connections to structures.

(G) Excessive bolt "stick through", exposed threads beyond the nut, more than ½ inch should be cut off. This is especially important where there is pedestrian or bicycle traffic behind the barrier. Excessive bolt length on beam barrier can increase sheet metal damage in otherwise minor collisions by vehicles. Threaded ends of bolts shall not be placed on the traffic side of the rail.

(H) Rail elements should be at the proper height for the type of barrier being installed.

Where the rail element is too low, less than 27 3/4 inches for metal beam guardrail and the Midwest Guardrail System, there is an increased chance that a vehicle may go over the top of the guardrail. Where a metal beam guardrail element is too high, more than 30 inches, and a Midwest Guardrail System element is too high, more than 32 inches, there is an increased chance of a small vehicle snagging on a post below the rail.

(I) The area in front of barriers should be flat and smooth, free of berms, dikes, curbs, windrows, watering basins, and ruts.

(J) Anchor cables should be taunt with no obvious slack in the cable. This will ensure that tension is quickly developed in the rail element during a collision and minimize any tendency towards pocketing of the vehicle.

(K) Concrete anchors and footings should be built according to dimension shown in the plans. Undersized footings, where soil has caved into the hole before concrete was placed, have been torn out of the ground by impacting vehicles.

- (L) Roadside rails may have longer posts or other design modifications when installed where the ground is loose or where there are steep side slopes. These modifications are made to provide additional lateral support to the posts. Be alert in recognizing these installations so they can be maintained as constructed.
- (M) Where cable clips are used, the saddle of the clip should be on the live or load carrying end of the cable. If not, the cable can slip, the rail will not develop full tension and a vehicle can penetrate the guardrail.
- (N) Avoid, if possible, making "off the cuff" field changes in planned installations. Small changes in an installation can result in greatly different performance during a collision.
- (O) Where there is a problem, or if something is not clear, ask questions. If you observe something that does not work the way it should, either in building it, maintaining it, or in expected performance, seek help through your district or Headquarters office.
- (P) Guardrail and barriers do not prevent accidents; they lessen the severity of collision when installed at justified locations.

**M3.03.2 Sand Filled Impact Energy Attenuators (Crash Cushions)**

- (A) Check the plans. Know what the installation requires.
- (B) Read manufacturer's installation instructions. Changes can occur. There are differences in manufacturer's designs.
- (C) Don't install barrels on soft ground or AC that is not compacted. The barrels will sink in unevenly, distorting the barrel and eventually leading to failure.
- (D) Open bottom (Fitch) barrels should not be installed on bare ground. Rodents can burrow underneath and into the barrel. An AC pad may prevent this. Also, water can more readily soften the ground under such barrels leading to its eventual failure.
- (E) Barrels should not hang over curbs on raised gore surfaces.
- (F) Weight of sand should be painted on pavement under or beside the barrel. This makes repairs easier.
- (G) Maintenance crews responsible for maintaining sand filled cushions should get a set of plans or drawings for each project showing the sand barrel pattern and sand weights in each barrel. This is especially important where sand weights have not or cannot be painted on the ground.

- (H) Lids should be pop-riveted to shells on Fitch barrels to minimize the lids flying about during an impact. The new lids are heavier, weighing 8 pounds to 10 pounds. If it is necessary to secure “Energite” or “Trafix” lids on barrels, they should be pop-riveted.
- (I) Energite Inner Cones and Fitch Sand Support Structures should be installed in accordance with the manufacturer’s instructions to ensure proper performance. Sand should be added to the levels indicated on the sides of the barrels.
- (J) Be sure that the sand meets specifications. Cleanliness is most important. Dirty sand can cake and result in split barrels. Very fine sand may slowly leak out. Do not use sand in bags. Use only loose sand.
- (K) Check the amount of sand in all barrels. Weights should conform to those shown on the plans.
- (L) Barrels with cracks through the walls that are permitting sand to leak out should be replaced as soon as possible. This assures the proper performance of the crash cushion.
- (M) If something is not understood or if you have questions, be sure to ask. Contact the Division of Maintenance or Division of Traffic Operations for questions.
- (N) All approved sand barrels (Energite, Fitch, and Traffix) may be mixed in an approved array, as long as the barrel has the proper sand weight for its array location. Note: the current Standard Plans have the approved arrays shown.

### **M3.04 Out of Control Vehicle Ramps**

Arrestor bed escape ramps require smoothing after every entry. An aggregate bed that contains humps and hollows can be very difficult to traverse and may unnecessarily damage the truck. Thus, it is essential that the aggregate bed be reshaped as soon as possible after a vehicle has been removed from the gravel.

Gravel tends to pack with time or repeated traversals by equipment. Thus, the gravel should be loosened up or scarified after each ten uses of the ramp or every six (6) months (Spring and Fall), whichever occurs more frequently. Whenever the gravel is scarified, it should be examined for contamination. Then, if an excessive amount of fine material or other contaminants is noted, immediate provisions should be made to replace or reprocess the aggregate to original specifications. Another indicator that the aggregate is becoming contaminated is when vehicles using the ramp travel increasing distances along the ramp. Use of the proper grade of stone cannot be over emphasized due to the potential liability.

Maintenance of an arrestor bed escape ramp requires adequate equipment. Hand tools are not acceptable. Proper power equipment assures that the ramp will be back in service in a minimum amount of time. It also ensures that Maintenance workers will be minimally exposed to the chance of a runaway truck wanting to use the ramp.

Equipment considerations may include a motor grader with an extension on its blade so the final pass in smoothing the gravel may be made from the service road. Another possibility is using a snow cat or some other light footprint vehicle. Since escape ramps are located in mountainous terrain and their use is more frequent in warm weather, the availability of snow cats is a possibility.012