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**Washington State
Department of Transportation**

Maintenance Manual

M 51-01.12

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Maintenance Operations

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8-1 General

Traffic services are maintenance functions necessary for the safe and efficient movement of traffic. These include maintaining highway signs, delineators, pavement markings, traffic islands, curbs, impact attenuators, barriers, guardrail, traffic signals, and highway illumination. Each serves a definite function in the control and guidance of traffic.

Functions that utilize electricity, including traffic signals, ramp meters, data accumulator systems, changeable message sign systems, and highway illumination systems are discussed in [Chapter 10](#).

The application, installation, and maintenance of all traffic service functions must conform to the accepted practice and standards set forth in the FHWA [Manual on Uniform Traffic Control Devices](#) (MUTCD), the WSDOT [Design Manual](#) M 22-01, and the WSDOT [Standard Plans](#) M 21-01.

8-2 Reconstruction Principles

The following are samples of items that are subject to reconstruction to meet current design standards. The list is not all-inclusive, but serves to illustrate the updating that can be accomplished.

- Breakaway bases on all sign supports and luminaire poles.
- Guardrail terminals and transitions.
- Guardrail post spacing.

Use the “K Job Estimating Application” in the HATS to estimate the cost of repairing damaged highway hardware in kind. When upgrading damaged hardware to current standards, attach a sheet to the Repair Cost Estimate to document why the original installation does not conform. This sheet will also show estimated additional materials, labor, and costs to bring the installation up to present design standards. Where possible, take photographs before and after repair and updating, and include in the job file.

Repair and updating is accomplished by state forces or by contract. On state force work, include the work order number to be charged against on employee time sheets. A standby contract will be used to provide early contractor mobilization to assure fast repair of critical highway hardware damage.

In a region level contract, the Regional Administrator awards a contract in accordance with the delegated authority for contracts. Guidance for administering region level contracts can be found in WSDOT [Advertisement and Award Manual](#) M 27-02. The amount of State Force Work participation in contracts is governed by the monetary limits shown in [Revised Code of Washington 47.28.030](#).

8-3 Signing

Highway signs are erected to convey specific messages to the traveling public. They provide regulatory, warning, and guidance information.

8-4 Signing Responsibility

The Regional Traffic Engineer has the authority for the design, location, height, and other features associated with the installation of new signs, and for any revisions that may become necessary.

Region maintenance personnel are responsible for maintaining signs once they are in place, in consultation with the Regional Traffic Engineer.

8-5 Sign Installation

Most signs are mounted at approximately right angles to approaching traffic. Parking signs may be installed at an angle 30 degrees or 45 degrees or even parallel to approaching traffic in order to provide visibility to vehicles adjacent to the sign.

Orientation. Normally, signs should be vertically-mounted at right angles to the direction of, and facing, the traffic that they are intended to serve. Where mirror reflection from the sign face is encountered to such a degree as to reduce legibility, the sign should be turned slightly away from the road. Signs that are placed 30 feet or more from the pavement edge should be turned toward the road. On curved alignments, the angle of placement should be determined by the direction of approaching traffic rather than by the roadway edge at the point where the sign is located.

8-5.1 Sign Clearance

Erect signs and their supports with maximum practical lateral and vertical clearance in accordance with the [MUTCD](#) or [Design Manual](#) M 22-01. This will provide the most safety for motorists who may accidentally leave the roadway.

The near edge of signs is normally located more than six feet outside the edge of shoulder or twelve feet from the edge of the traveled lane. Where curb exists, locate the near edge of the sign no less than two feet from the face of the curb.

Take care when installing signs and their supports behind roadside barriers. Many barriers are designed to deflect upon impact. An inappropriately located sign or support within that area could prevent proper functioning of the barrier and may result in a potentially hazardous situation. Do not locate signs or supports within the deflection areas listed in 1610.03(3).

Barrier Type	System Type	Deflection
High-tension cable barrier	Flexible	6 ft to 10 ft typical [1] (face of barrier to object)
Beam guardrail, Type 1, 1a, and 10	Semi-rigid	3 ft [4] (face of barrier to object)
Beam guardrail, two-sided Types 3 and 4	Semi-rigid	4 ft (nearest face of barrier to object)
Beam guardrail Type 31 (including two-sided and omitted post)	Semi-rigid	5 ft (face of barrier to object)
Permanent precast concrete barrier, unanchored	Rigid Unrestrained	6 ft [2] (back of barrier to object)
Temporary precast concrete barrier, unanchored [5]	Rigid Unrestrained	3 ft [3] (back of barrier to object)
Permanent precast concrete barrier anchored	Rigid Anchored	2 ft (back of barrier to object)
Temporary precast concrete barrier, anchored [5]	Rigid Anchored	1 ft [3] [6] (back of barrier to object)
Cast in place or precast concrete barrier, embedded	Rigid Embedded	No deflection [7]

Use two checks when determining the height of post-mounted signs.

1. Assure the vertical clearance from the bottom of the sign to the roadway surface meets MUTCD specifications. This ensures good visibility.
2. Install signs as shown in the standard plans. This ensures that the safety mechanism (i.e., breakaway, slip base, load concentrating coupling, etc.) of the support system will function properly.

8-6 Maintenance

Keep all signs in proper position, clean, and legible. Conduct periodic day and night inspections for position, damage, legibility, and general condition. In addition, check sign structures and sign-to-structure connections for structural integrity.

8-6.1 Inspection

In snowy areas, signs may be damaged by plows or by thrown snow or ice. Inspections are most effective after the winter weather has ended. Another inspection is recommended in the fall to ensure readiness for winter driving. In areas where weather is less severe, inspections may be correlated with other maintenance work.

Periodically check sign bridge and cantilever structure end post and metal sign post base connections. In addition, inspect sign mounting bolts and beam clips for proper tightness. Replace or secure missing or loose hand hole covers on overhead sign structure supports. Give special attention to steel sign post base and fuse plate connections. To properly function as a breakaway support while resisting wind loading, the bolt torque specified in the standard plans must be maintained.

8-6.2 *Field Repair*

Good judgment and sound economics dictate when to perform field repairs. Field repair minor sign damage whenever possible. More extensive damage normally requires sign replacement. Signs such as STOP and YIELD, whose absence can be life threatening, must receive priority replacement.

Signs that are repeatedly knocked down by vehicles may be reinstalled farther away from the roadway or at a different location along the roadway. Care must be taken to ensure that the new location meets MUTCD requirements.

Sign supports within the “clear zone” described in [Chapter 2](#) must meet functional requirements of current safety standards. Sign support design elements are shown in the standard plans.

Never weld the steel sign post web to prevent wind blow-down. Proper fuse plate bolts and bolt torque will prevent blow-down.

Along with proper bolt torque, the area around the sign post base must be clear of obstructions that may prevent the post from slipping free of the base. Ensure that the base stub-post does not project more than 4 inches above the ground. Projections above that height may snag the under-carriage of a vehicle.

8-7 **Sign Visibility**

Promptly remove obstructions that prevent adequate sign visibility. Vegetation trimming is sometimes necessary to ensure adequate sign visibility. Maintenance crews must be particularly careful to avoid parking equipment in front of traffic signs.

At times, highway sign faces are obscured as a result of roadway snow removal. Clear all signs as soon as possible. Regulatory and warning signs have first priority.

8-8 **Sign Storage and Transportation**

Store signs indoors whenever possible to prevent sign sheeting failure. The signs may be packaged if dry. If packaged signs become wet, immediately unpack and separate them to allow drying.

At times, it is necessary to store signs outside. In this situation, remove the packing materials so that nothing is against the sign face. Never lay signs flat. Water accumulating between signs laying flat will cause sign sheeting failure.

Store signs upright on edge on blocks or other material to keep the signs off the ground. Install spacers along the sign edges to allow air circulation and normal moisture evaporation from the sign face. Avoid sign sheeting contact with treated wood. Avoid storage where dirt or water may splash on the sign face.

Transport signs on edge, face to face or back to back, to prevent sign face damage.

8-9 Delineation

Delineation is defined as one, or a combination of devices, (excluding signing), that warn or provide guidance to the roadway user. These devices include pavement markings, guideposts, guardrail delineators, and barrier delineators. Delineation of environmentally sensitive areas are identified with specifically marked green guideposts.

8-10 Pavement Markings

Pavement markings are divided into two categories – long line and transverse and symbol. Long line markings are the markings that are applied parallel to the roadway. Typically long line markings are renewed with a spray application of new material applied from a striping truck. Transverse and symbol markings are typically renewed by hand, by spray, or extruded application of new material.

Long line markings include the following – center line, no-pass line, double center line, double lane line, wide lane line, double wide lane line, lane line, edge line, solid lane line, dotted extension line, wide dotted lane line, wide broken lane line, drop lane line, barrier center line, two way left turn center line, and reversible lane line.

Transverse markings include the following – Crosswalk line, stop line and wide line. Symbol markings include the following:

- Traffic arrows
- Traffic letters
- Access parking space symbol
- High occupancy vehicle (HOV) lane symbols
- Railroad crossing symbols
- Bicycle lane symbols
- Drainage markings
- Aerial surveillance markers

Raised pavement markers (RPMs) are installed either as positioning guides along with longitudinal markings or they are installed as a complete substitute for long line markings. Surface mounted RPMs are installed on roadways where snow removal operations use rubber blades. Recessed RPM applications consist of the installation of an RPM in a groove that has been cut into the pavement. Recessed RPM applications are allowed in areas where snow removal operations use steel blades. Various markings are identified by color code as follows:

RPM Type	Color
Type 1W	White Non-Reflective
Type 1Y	Yellow Non-Reflective
Type 2W	White One Side Only
Type 2WR	White and Red
Type 2Y	Yellow One Side Only
Type 2YY	Yellow Both Sides
Type 2YR	Yellow and Red

Descriptions and dimensions of markings are shown in the [Standard Plans](#), Section M, Pavement Markings. Application requirements for various markings are shown on the standard plans, noted by type as follows:

Marking Application	Standard Plan
Longitudinal Marking Patterns	M-20.10
Profiled and Embossed Plastic Lines	M-20.20
Longitudinal Marking Supplemented with RPMs	M-20.30
Longitudinal Marking Supplement with RPM's ~ Turn Lanes	M-20.40
Longitudinal Marking Substitution with RPMs	M-20.50
Left Turn Channelization	M-3.10, M-3.20, M-3.30, and M-3.50
Two-Way Left-Turn and Median Channelization	M-3.40
Off-Ramp Gore Area Marking	M-2.20
Ramp Channelization Single Lane	M-1.20
Ramp Channelization Two Lane	M-1.40
Ramp Channelization Collector – Distributor Road	M-1.60
Symbol Markings ~ Traffic Arrows for Low Speed Roadways	M-24.20 and M-24.40
Bicycle Lane Symbol Layout	M-9.50
Crosswalk Layout	M-15.10
High Occupancy Vehicle (HOV) Lane Symbol Layout	M-7.50
Symbol Markings Miscellaneous	M-24.60
Aerial Surveillance Marking	M-24.60
Railroad Crossing Layout	M-11.10
Roundabout Traffic Arrows	M-24.40

RPMs installed as positioning guides along with longitudinal markings are shown on [Standard Plans](#) M-20.30 and M-20.40. RPMs installed as substitute applications for longitudinal markings are shown on [Standard Plans](#) M-20.50.

8-11 Materials

Pavement markings are renewed with a material that is compatible with the original application material. Painted markings are renewed at a thickness of 0.015 inches or 15 mils. The glass beads are applied at a minimum rate of seven pounds per gallon of paint. Thermoplastic markings are renewed at a thickness of 45 mils for long line markings and 90 mils for transverse markings. Methylmethacrylate markings are renewed at a thickness of 45 mils for long line markings and 90 mils for transverse markings. RPMs are replaced in kind.

8-12 Application

All materials shall be applied when the pavement is clean and dry since pavement moisture is the major cause of most marking failures. The Striping Supervisor is advised to contact the area Maintenance Supervisor in advance of any long line marking applications to coordinate maintenance activities and arrange for sweeping of the roadways.

Pavement marking materials are to be applied in accordance with the material manufacturer's recommendation. Apply paint and thermoplastic materials when the pavement temperature is 50 degrees and rising. Methylmethacrylate material can be applied when the pavement temperature is 40 degrees and rising, provided the pavement is dry.

Paint and methylmethacrylate material is purchased by the liquid gallon. Thermoplastic material is purchased by the pound, then heated and applied as liquid. Material requirements for pavement marking materials for a continuous four inch line are as follows:

Millage	Gallons/Mile (Liquid)	Pounds/Mile (Dry)
15	16.4	–
45	49.2	1100
90	98.3	2200

8-13 Surface Moisture Test

The presence of moisture on the pavement should be checked whenever conditions are questionable. Presence of pavement surface moisture can be determined as follows:

- **Asphalt or Concrete Surfaces** – Place a 12 × 12 inch square piece of plastic wrap on the pavement surface using duct tape to affix the edges. Let stand approximately 15 minutes and check for moisture bubbles on the inside surface of the plastic. If moisture bubbles on the plastic are larger than a pencil eraser, then the pavement contains too much excess water. Notify the contractor of this condition and postpone all marking operation until the pavement is dry enough to prevent the large moisture bubbles from forming on the plastic.
- **Thermoplastic Applications on Asphalt Only** – Using roofing felt paper, place a 12 × 12 inch square of felt on the asphalt and install the thermoplastic material directly onto the felt paper. Let it cool for approximately 10 seconds, then lift the paper to check for moisture on the back side. If moisture bubbles larger than a pencil eraser are present on the back side of the roofing paper, then the pavement contains too much excess water. Notify the contractor of this condition and postpone all marking operations until the pavement is dry enough to prevent the large moisture bubbles from forming on the back of the felt paper.

8-14 Marking Renewal or Replacement Frequency

Pavement markings are renewed when they no longer provide guidance during daytime and nighttime conditions. Markings that may appear adequate in the daytime may have no reflectivity at night. Typically markings fail by loss of reflectivity long before they fail by daytime appearance.

On the majority of our highways, the longitudinal paint stripes will have to be restriped every year to maintain adequate line presence and retroreflectivity.

On low volume highways with minimal snow plowing activity, paint striping may last more than one year. A stripe evaluation should be done that evaluates both the amount of paint remaining on the roadway surface (durability) and the retroreflectivity of the stripe. The study should determine if the stripe will remain adequate until the next striping maintenance cycle.

The frequency renewal rates can vary depending on a number of factors to include traffic, weather and plow damage to name a few. In general, renew applications typically occur on the following schedule:

Marking Type	Frequency
Long line painted markings	At least once a year or less determined by evaluation
Heavy wear long line painted markings	At least once a year or less determined by evaluation
Thermoplastic transverse applications	At least once every two years
Methylmethacrylate transverse applications	Every five years
Reflective RPMs (except yellow)	By group every two years
Reflective yellow RPMs supplementing the yellow edge lines on divided highways	Every four years
Non reflective RPMs	Replaced as needed when the associated reflective RPMs are replaced

8-15 Removal of Markings

Removed pavement markings can sometimes reappear and confuse motorists. All removed pavement markings must be unidentifiable as pavement markings under day or night, wet or dry conditions.

Do not over-paint markings with black paint or bituminous solutions. This treatment has proven unsatisfactory because the original lines eventually reappear as the overlying material wears away. In addition, lines covered in this manner may still be visible under wet conditions or low angle illumination (headlights) conditions.

8-16 Guideposts

Guideposts are classified as guide markings rather than required warning devices. Guidepost type designations and mounting details are noted on Standard Plan M-40.10. Guidepost placement guidelines are noted in Standard Plan M-40.20 through M-40.60.

Studies have shown that wildlife warning reflector systems are ineffective at reducing the accident potential for motor vehicle/wildlife collisions. WSDOT policy is to no longer design, place, or maintain wildlife reflectors.

Barrier delineation is used in areas with guardrail or concrete barrier where guideposts are required by other roadway conditions. The spacing of barrier delineators for these applications is the same as the spacing noted for guideposts. Promptly replace damaged or missing guideposts and barrier delineators.

8-17 Roadside Safety Hardware

Roadside safety hardware (referred to as simply “hardware” in this section) includes impact attenuators, roadside barriers (beam guardrail, cable barrier, and concrete barrier), guardrail terminals and transitions. This hardware is used to reduce the severity of vehicle crashes in situations where issues identified in the Design Clear Zone (as defined in [Chapter 2](#)) cannot be mitigated by removal, relocation, or redesign. Among the roadside issues to consider for mitigation are steep slopes, water bodies, and non-breakaway fixed objects. Roadside barrier components include the barrier standard run, terminals or anchors provided at the barrier ends, and transitions that connect barriers with differing stiffness characteristics. Impact attenuators are standalone devices used to shield non-breakaway features.

Install MASH compliant roadside safety hardware in all new construction and full maintenance replacements, except where otherwise noted below or in the HATS file library.

8-18 Maintenance

Barriers must be properly maintained to ensure that they will perform as intended when struck by a vehicles. Keep the area under and around barriers clean and free of debris. Do not attach objects to hardware where it is not supported or specified by the designer or manufacturer. The area under and around barriers may or may not need to be kept free of vegetation. This is a site-specific decision based on types of vegetation and the hardware’s design and function.

8-19 Inspection – General

Inspect barriers periodically, either by visual drive-by or by physical inspections.

Inspect for:

- The overall condition of the barrier (including posts).
- Proper interconnection of units.
- Proper installation of anchor cables and connecting pins.
- Tightness of blocks and fasteners.
- Proper overlapping of beam guardrail.
- Secure attachment of beam guardrail.

8-20 Repair

Repair damaged roadside safety hardware within two weeks of when the damage is documented, unless higher documented priorities preempt action. If possible, determine whether damaged hardware will be repaired, replaced, or removed. Document all repair work in HATS.

Following an assessment of a field repair situation, region Maintenance personnel may need additional guidance, for example when considering whether to repair or replace non-standard safety hardware. In these situations, it is advised that Maintenance personnel seek initial guidance from regional Maintenance staff experienced in roadside safety hardware repair/installation, region Trainers, or the HQ Maintenance office. There may be additional situations where region Maintenance staff have identified potential changes to or potential removal of roadside hardware that could provide advantages to the traveling public safety or ongoing operations. Examples of safety hardware removal opportunities include locations where a slope can be flattened, or where a fixed object could be removed.

If the proposed safety hardware solution involves removal of the hardware, a significant revision to any aspect of the safety hardware, or a significant construction effort; the region Maintenance staff will need to work collaboratively with their assigned region Traffic Design. The collaboration with the Region Traffic Design contact will consider, analyze, and determine the best safety hardware revision option for the location, and whether region maintenance forces or a future region project is best equipped to install the selected revision option. If the safety hardware revision is programmed into a future project, region maintenance will determine and install (following consultation with the region traffic design contact) a temporary roadside hardware repair or installation to be used at the location until such time as the upcoming project can implement the revision. Document in HATS the safety hardware repair alternatives considered, and the rationale for selecting the safety hardware repair, revision, or removal alternative.

8-21 Inspection and Preventive Maintenance – Cable Barrier

All cable barrier should be inspected and re-tensioned annually, as recommended by cable barrier system manufacturers. The inspection shall consist of a maintenance technician walking along the run of barrier, visually observing barrier components to determine any deficiencies and the overall condition of the barrier. The inspection should also include measuring the tension and re-setting the tension to the recommended requirements. All inspection and preventive maintenance work shall be documented in HATS.

8-22 Standard Run of Barrier

The standard run of barrier is the majority of the barrier run. It includes all of the barrier except the terminals and transition sections. Because barrier designs evolve over time, consider upgrading the entire run using to the most recent standard barrier when a significant portion has been damaged. For minor repairs, upgrade the damaged portion of barrier to current standards (post spacing, block outs, etc.), unless it's determined not to be practical.

Document decisions in HATS to not upgrade hardware during a repair.

8-23 Terminals and Anchors

A guardrail anchor is required at the ends of a standard run of guardrail to develop its tensile strength throughout its length. In addition, when the end of any barrier is subject to head-on impacts, a crash worthy terminal is required. Guardrail anchorage may be provided as part of the terminal, as a connection to a rigid structure, or by an anchor whose only purpose is to strengthen the run.

Many different terminal designs have been used on Washington State highways, the most recent having been tested to MASH standards. Replace damaged terminals that cannot be repaired replaced MASH standard designs. Refer to the [Repair and Replacement of Guardrail Terminal](#) in the HATS File Library and search.

Common features of non-crash worthy designs are as follows:

- No cable anchor.
- A cable anchored into concrete in front of the first post.
- Second post not breakaway (CRT).
- Design A end section (Design C end sections are acceptable to be left in place).
- Beam guardrail on both sides of the posts (two sided).

A common terminal that was used on Washington State highways is the Breakaway Cable Terminal (BCT). These terminals included a Type 1 anchor and a parabolic flare that offset the end four feet from the tangent run of guardrail. Replace BCTs that have sustained damage, requiring replacement of one post or one rail section to a MASH compliant terminal.

When replacing a terminal consider the feasibility of extending the run to a cut slope where a buried terminal may be installed instead.

8-24 Transitions

Transitions are used to stiffen a system, such as w-beam guardrail before a more rigid barrier such as a bridge rail. Stiffening is accomplished by nesting the rail elements, using bigger posts and reducing the post spacing. The transitions that are currently used are shown in the [Standard Plans](#) beginning at C-25.20 and vary depending on the transition section type.

8-25 Impact Attenuators

Impact attenuators can be used as an end treatment for barriers or to prevent vehicles from impacting non-breakaway fixed objects. When installing or repairing an attenuator, document (in HATS) the brand, layout showing parts order numbers, module locations and weights, and provide photographs of the device.

Install MASH compliant attenuators in all new construction and full maintenance replacements of attenuators, except as indicated below. Manufacturers may limit site conditions, such as cross slope and curb height, in which their devices are allowed to be installed. Existing NCHRP 350 compliant attenuators may remain in place and repaired.

New NCHRP 350 attenuators are allowed where installation of a MASH compliant device is not feasible. Document the decision to use an NCHRP 350 device. Use the impact attenuator selection template in the HATS file library when selecting attenuators.

8-25.1 Maintenance

Replace and repair impact attenuators in accordance with the manufacturer's recommendations. Check for proper restraining cable tightness, anchor bolt tightness, diaphragm and hardware in good condition, and fender panels securely in place.

Sand barrel designs may be proprietary or generic.

Inspect proprietary designs according to manufacturer's guidance and/or specifications. Inspect generic sand barrels as follows:

- Lids are firmly in place and not dented.
- No visible damage or cracks in the outer shell.

Each barrel is filled with the correct amount of dry sand or dry pea gravel. (See original specifications)

No visible moisture inside the barrels. If the sand is found to contain moisture, mix salt with the sand at a rate of 10 percent to 20 percent (by volume) to prevent freezing. Some sand may need to be discarded before adding the salt to prevent overfilling the barrel.

For water filled designs, replace damaged water cell units. A damaged cell may be left in place temporarily as long as it's not leakage.

8-26 Islands

Islands must be properly maintained to provide protection of motorists and pedestrians. Keep island passageways clear of debris. Repaint outlines of islands as directed by the Regional Traffic Engineer. Replace missing or damaged raised pavement markers when more than three consecutive markers are missing.

Displaced or missing raised curb must be repositioned or replaced. Paint raised curb as directed by the Regional Traffic Engineer.

8-27 Transit Vehicle Stop Zones

8-27.1 *Maintenance*

Transit stops along state highways outside cities are maintained by the state. These locations should be kept free of debris, potholes and other obstacles that could cause tripping. The responsibility for maintaining transit stops on state highways inside cities is covered in the agreement discussed in the Traffic Manual's transit vehicle stop zone guidelines. An inventory of transit stops is available at the Regional Traffic Office.

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