

Maintaining Traffic Sign Retroreflectivity (2005 Edition)

Retroreflectivity . . .



NIGHT LIGHTS

...lighting the way

- Provides critical information to drivers at night
- Helps drivers navigate the road during nighttime hours
- Enhances traffic flow and driver mobility, and

...Promotes Safe Driving!

For more information contact the FHWA:

Debra Chappell, 202-366-0087
Greg Schertz, 720-963-3764

Web site: safety.fhwa.dot.gov/retro



U.S. Department of Transportation
Federal Highway Administration

Traffic signs provide an important means of communicating information to road users and signs need to be visible to be effective. The 2003 Manual on Uniform Traffic Control Devices (MUTCD) addresses sign visibility in several places, including Sections 1A.03, 1A.04, 1A.05, 2A.06, 2A.08, and 2A.22. Visibility is addressed in portions of these Sections through factors such as design, placement, operation, maintenance, and uniformity.

Sign visibility encompasses additional considerations as well. Conspicuity and legibility are two key elements of visibility. Sign conspicuity and legibility are needed during daytime and nighttime conditions.

Conspicuity is the ability to detect signs within their surroundings. Legibility is the ability to determine the message (content) of the sign. It is what helps the user read the word message on a sign or to discern the shape of the symbol on a sign.

The nighttime condition presents many sign visibility challenges. At night, road users cannot see as many visual cues as they can during the day. This places greater reliance on signs and other traffic control devices. To provide nighttime sign conspicuity and legibility, most signs are made from retroreflective sheeting. Retroreflective sheeting redirects incident light back toward the vehicle. It is what helps make signs visible during nighttime conditions.

Existing procedures and technologies for measuring sign retroreflectivity provide one, but not the only, means of quantifying nighttime sign visibility. The Federal Highway Administration (FHWA) has focused significant attention on retroreflectivity in recent years, including developing proposed minimum maintained levels of sign retroreflectivity.

Sign location and orientation also impact sign visibility. A sign

placed outside of a driver's cone of vision might not be seen by the driver even though the sign meets other visibility criteria. Likewise, signs behind obstructions (such as a structure or vegetation) might meet some visibility criteria, but still might not be seen by drivers. To provide maximum effectiveness, signs should be designed, placed, and maintained in a manner that is consistent with MUTCD guidelines.

This document provides supplemental information about the methods that can be used to maintain sign retroreflectivity at or above FHWA's proposed minimum maintained retroreflectivity levels. Information contained in this document is intended for policymakers and managers. A separate FHWA document providing additional detail about the various methods to maintain sign retroreflectivity is being developed.

RETROREFLECTIVITY MAINTENANCE

There are several methods that agencies can use to maintain sign retroreflectivity at or above the FHWA proposed minimum maintained retroreflectivity levels, which were developed to provide transportation agencies with a general target for maintaining sign retroreflectivity. The existence of minimum retroreflectivity levels is not intended to imply that an agency needs to measure the retroreflectivity of every sign in its jurisdiction. Instead, the methods described in this document provide agencies with options that will help them improve the nighttime visibility of their signs.

Sign maintenance methods can be divided into two groups – assessment methods and management methods. Assessment methods involve the actual evaluation of individual signs, while management

methods involve tracking and/or predicting the retroreflectivity of groups of signs. The FHWA has identified several assessment and management methods for maintaining sign retroreflectivity in a manner that is consistent with the proposed minimum retroreflectivity levels. Agencies also have the flexibility to develop their own methods for maintaining sign retroreflectivity.

ASSESSMENT METHODS

The assessment methods require evaluation of individual signs within an agency's jurisdiction. There are two basic assessment methods – visual assessment and retroreflectivity measurement.

Visual Nighttime Inspection Method

The visual nighttime inspection method is probably the most consistent with the current practices of many agencies. Visual inspections are also currently recommended in Section 2A.22 of the MUTCD.

In the visual nighttime inspection method, on-the-fly assessments of visibility and retroreflectivity are made by the inspector. Signs need to be replaced if they do not meet the comparison defined in the appropriate procedure. The following recommendations provide general guidance for the inspections:

- Agencies develop guidelines and procedures for inspectors to use in conducting the nighttime inspections. Inspectors are trained on the use of these procedures.
- The inspection is conducted at normal roadway operating speeds. Signs are usually inspected from the travel lane.
- The inspection is conducted using the low-beam headlights and no or little interior vehicle lighting.
- Signs are normally evaluated at a typical viewing distance for each sign, one that provides a driver with adequate time for an appropriate response.

In addition to the preceding guidance, one or more of the following procedures can be used to support the connection between visual inspections and the proposed minimum maintained retroreflectivity levels.

Calibration Signs Procedure

Calibration signs are viewed by the inspector prior to conducting the nighttime inspection. The calibration signs have retroreflectivity levels at or above the proposed minimum levels. These signs are set up where the inspector can view the calibration signs in a manner similar to how the nighttime field inspection will be conducted. The inspector uses the visual appearance of the calibration sign to establish the evaluation threshold for that night's inspection activities. The following factors provide additional information on the use of this procedure:

- Calibration signs are needed for each color of sign for which there are minimum retroreflectivity levels.
- The calibration signs are viewed at typical viewing distances and from the same vehicle that will be used for conducting the field inspections.
- The calibration signs need to be properly stored between inspections so that the retroreflectivity of the calibration signs does not deteriorate over time. Calibration sign retroreflectivity needs to be checked at periodic intervals to ensure that the calibration panels have the appropriate retroreflectivity levels.

The sign needs to be replaced if the inspector judges the sign to be less bright than the appropriate calibration sign.

Comparison Panels Procedure

Small comparison panels are used to assess the retroreflectivity of questionable signs. The comparison panels are fabricated at retroreflectivity levels that are at or above the proposed minimum levels. When the

retroreflectivity of a sign is considered to be questionable, a comparison panel is attached to the sign and the sign/panel combination is viewed by the inspector. The sign needs to be replaced if the comparison panel appears to be brighter than the sign.

Consistent Parameters Procedure

The same factors that were used to develop the proposed minimum levels should be used in conducting the inspections. These factors include:

- Using a full-size sport utility vehicle or pick-up to conduct the inspection.
- Using a model year 2000 or newer vehicle for the inspection.
- Using an inspector who is at least 60 years old.
- Viewing signs at the typical viewing distance for that sign.

The sign needs to be replaced if it is not legible to the inspector.

Measured Retroreflectivity Method

In this method, the retroreflectivity of a sign is measured and directly compared to the proposed minimum level appropriate for that sign. ASTM E1709, Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflector, provides a standard method for measuring sign retroreflectivity using a hand-held retroreflector. The sign needs to be replaced if its average retroreflectivity value is less than the appropriate proposed minimum level.

MANAGEMENT METHODS

The management methods provide an agency with the ability to maintain sign retroreflectivity without having to devote the significant effort that is required to assess individual signs. There are three basic types of management methods – replacing signs based on age, blanket replacement of large numbers of signs at appropriate intervals, and using a sample of control signs to determine when to replace equivalent signs.

Expected Sign Life Method

In this method, individual signs are replaced before they reach the end of their expected service life. The expected service life is based on the time required for the retroreflective material to degrade to a value that is less than the appropriate proposed minimum level. The expected service life of a sign can be based on several factors, such as:

- Sign sheeting warranties,
- Weathering deck results, or
- Measurements of actual signs.

Potential methods to identify the age of individual signs include:

- A sticker or other label attached to the back of the sign that identifies the year of fabrication, installation, and/or replacement.
- A sign management system that keeps track of the age of individual signs.

Blanket Replacement Method

In this method, an agency replaces all of the signs in an area or corridor, or of a given type, at specified intervals. An agency that uses this method does not need to track the age or assess the retroreflectivity of individual signs.

- Replacement zones can be based on an area, corridor, or sign type.
- The replacement interval for the area, corridor, or sign type is based on the expected sign life for the affected signs.
- All signs within a replacement area or corridor or of a particular sign type are typically replaced, even if the sign was recently installed.

Control Sign Method

In this method, a control sample of signs is used to represent the total population of an agency's signs. The retroreflectivity of the control signs is monitored at appropriate intervals and sign replacement is based on the performance of the control signs.

- An agency needs to develop a sampling plan to determine the appropriate number of control

signs that are needed to represent the agency's sign population.

- Control signs may be actual signs in the field or may be signs installed in a maintenance yard to serve specifically as control signs.
- The retroreflectivity of the control signs should be monitored following the procedures outlined for one of the assessment methods.
- All field signs represented by the control sample need to be replaced before the retroreflectivity levels of the control sample reach the proposed minimum levels.

SIGN REPLACEMENT

All of the sign retroreflectivity maintenance methods indicate that signs need to be replaced when they do not meet the threshold criteria for the individual method. In maintaining sign retroreflectivity, an agency might want to consider in the sign evaluation and replacement process the amount of time remaining until the next assessment or management event will take place. In some cases, it might be appropriate to replace a sign even though it is above the threshold criteria because it could be expected to drop below the threshold criteria before the next assessment or management event.

SIGN EXCLUSIONS

The following signs may be excluded from the various methods of maintaining sign retroreflectivity:

- Parking, Standing, and Stopping signs (R7 and R8 series).
- Walking/Hitchhiking/Crossing signs (R9 series, R10-1 through R10-4b).
- Adopt-A-Highway signs.
- Signs with blue or brown backgrounds.
- Bikeways signs that are intended for exclusive use by bicyclists or pedestrians.

MINIMUM RETROREFLECTIVITY LEVELS

The FHWA has sponsored several research efforts to develop recommendations for minimum retroreflectivity levels for traffic signs. The initially proposed minimum retroreflectivity levels were published in 1993 (1). These levels were revised in 1998 through further research (2). Updated minimum levels were developed in 2003 (3). The minimum levels published in 2003 are the levels that the FHWA proposes to use in the MUTCD. Each research effort is described further in a recent TRB publication (4).

The minimum maintained sign retroreflectivity levels proposed in 2003 include the following considerations:

- Improved retroreflectivity data and modeling were used to develop the minimum levels.
- New types of sheeting were incorporated into the minimum levels.
- Headlamp (headlight) performance was updated to represent the model year 2000 vehicle fleet.
- Vehicle size was increased to represent the greater prevalence of sport utility vehicles and pickup trucks.
- Increased emphasis was given to accommodating older drivers by adjusting the required luminance levels.
- Minimum retroreflectivity levels were consolidated across several factors, such as sign size and sheeting type, to reduce the complexity of proposed minimum levels.

The proposed minimum maintained retroreflectivity levels are shown on the next page. The assumptions and limitations associated with the proposed levels are described in the research report (3).

It should be noted that there might be situations where, based on engineering judgment, an agency may want to provide higher retroreflectivity.

Minimum Maintained Retroreflectivity Levels^①

Sign Color	Sheeting Type (ASTM D4956-04)				Additional Criteria			
	Beaded Sheeting			Prismatic Sheeting				
	I	II	III	III, IV, VI, VII, VIII, IX, X				
White on Green	W*; G ≥ 7	W*; G ≥ 15	W*; G ≥ 25	W ≥ 250; G ≥ 25	Overhead			
	W*; G ≥ 7	W ≥ 120; G ≥ 15			Ground-mounted			
Black on Yellow or Black on Orange	Y*; O*	Y ≥ 50; O ≥ 50			②			
	Y*; O*	Y ≥ 75; O ≥ 75			③			
White on Red	W ≥ 35; R ≥ 7				④			
Black on White	W ≥ 50				—			
<p>① The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m² measured at an observation angle of 0.2° and an entrance angle of -4.0°.</p> <p>② For text and fine symbol signs measuring at least 1200 mm (48 in) and for all sizes of bold symbol signs</p> <p>③ For text and fine symbol signs measuring less than 1200 mm (48 in)</p> <p>④ Minimum Sign Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)</p> <p>* This sheeting type should not be used for this color for this application.</p>								
Bold Symbol Signs								
<table style="width: 100%; border: none;"> <tr> <td style="vertical-align: top; width: 33%;"> <ul style="list-style-type: none"> • W1-1, -2 – Turn and Curve • W1-3, -4 – Reverse Turn and Curve • W1-5 – Winding Road • W1-6, -7 – Large Arrow • W1-8 – Chevron • W1-10 – Intersection in Curve • W1-11 – Hairpin Curve • W1-15 – 270 Degree Loop • W2-1 – Cross Road • W2-2, -3 – Side Road • W2-4, -5 – T and Y Intersection • W2-6 – Circular Intersection </td> <td style="vertical-align: top; width: 33%;"> <ul style="list-style-type: none"> • W3-1 – Stop Ahead • W3-2 – Yield Ahead • W3-3 – Signal Ahead • W4-1 – Merge • W4-2 – Lane Ends • W4-3 – Added Lane • W4-5 – Entering Roadway Merge • W4-6 – Entering Roadway Added Lane • W6-1, -2 – Divided Highway Begins and Ends • W6-3 – Two-Way Traffic • W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning </td> <td style="vertical-align: top; width: 33%;"> <ul style="list-style-type: none"> • W11-2 – Pedestrian Crossing • W11-3 – Deer Crossing • W11-4 – Cattle Crossing • W11-5 – Farm Equipment • W11-6 – Snowmobile Crossing • W11-7 – Equestrian Crossing • W11-8 – Fire Station • W11-10 – Truck Crossing • W12-1 – Double Arrow • W16-5p, -6p, -7p – Pointing Arrow Plaques • W20-7a – Flagger • W21-1a – Worker </td> </tr> </table>						<ul style="list-style-type: none"> • W1-1, -2 – Turn and Curve • W1-3, -4 – Reverse Turn and Curve • W1-5 – Winding Road • W1-6, -7 – Large Arrow • W1-8 – Chevron • W1-10 – Intersection in Curve • W1-11 – Hairpin Curve • W1-15 – 270 Degree Loop • W2-1 – Cross Road • W2-2, -3 – Side Road • W2-4, -5 – T and Y Intersection • W2-6 – Circular Intersection 	<ul style="list-style-type: none"> • W3-1 – Stop Ahead • W3-2 – Yield Ahead • W3-3 – Signal Ahead • W4-1 – Merge • W4-2 – Lane Ends • W4-3 – Added Lane • W4-5 – Entering Roadway Merge • W4-6 – Entering Roadway Added Lane • W6-1, -2 – Divided Highway Begins and Ends • W6-3 – Two-Way Traffic • W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning 	<ul style="list-style-type: none"> • W11-2 – Pedestrian Crossing • W11-3 – Deer Crossing • W11-4 – Cattle Crossing • W11-5 – Farm Equipment • W11-6 – Snowmobile Crossing • W11-7 – Equestrian Crossing • W11-8 – Fire Station • W11-10 – Truck Crossing • W12-1 – Double Arrow • W16-5p, -6p, -7p – Pointing Arrow Plaques • W20-7a – Flagger • W21-1a – Worker
<ul style="list-style-type: none"> • W1-1, -2 – Turn and Curve • W1-3, -4 – Reverse Turn and Curve • W1-5 – Winding Road • W1-6, -7 – Large Arrow • W1-8 – Chevron • W1-10 – Intersection in Curve • W1-11 – Hairpin Curve • W1-15 – 270 Degree Loop • W2-1 – Cross Road • W2-2, -3 – Side Road • W2-4, -5 – T and Y Intersection • W2-6 – Circular Intersection 	<ul style="list-style-type: none"> • W3-1 – Stop Ahead • W3-2 – Yield Ahead • W3-3 – Signal Ahead • W4-1 – Merge • W4-2 – Lane Ends • W4-3 – Added Lane • W4-5 – Entering Roadway Merge • W4-6 – Entering Roadway Added Lane • W6-1, -2 – Divided Highway Begins and Ends • W6-3 – Two-Way Traffic • W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning 	<ul style="list-style-type: none"> • W11-2 – Pedestrian Crossing • W11-3 – Deer Crossing • W11-4 – Cattle Crossing • W11-5 – Farm Equipment • W11-6 – Snowmobile Crossing • W11-7 – Equestrian Crossing • W11-8 – Fire Station • W11-10 – Truck Crossing • W12-1 – Double Arrow • W16-5p, -6p, -7p – Pointing Arrow Plaques • W20-7a – Flagger • W21-1a – Worker 						
Fine Symbol Signs – Symbol signs not listed as Bold Symbol Signs.								
Special Cases								
<ul style="list-style-type: none"> • W3-1 – Stop Ahead: Red retroreflectivity ≥ 7 • W3-2 – Yield Ahead: Red retroreflectivity ≥ 7; White retroreflectivity ≥ 35 • W3-3 – Signal Ahead: Red retroreflectivity ≥ 7; Green retroreflectivity ≥ 7 • W3-5 – Speed Reduction: White retroreflectivity ≥ 50 • For non-diamond shaped signs such as W14-3 (No Passing Zone), W4-4p (Cross Traffic Does Not Stop), or W13-1, -2, -3, -5 (Speed Advisory Plaques), use largest sign dimension to determine proper minimum retroreflectivity level. 								

REFERENCES

1. Paniati, J.F. and D.J. Mace. *Minimum Retroreflectivity Requirements for Traffic Signs, Technical Report*. FHWA-RD-93-077, Federal Highway Administration, Washington, D.C., October 1993.
2. McGee, H.W. and J.F. Paniati. *An Implementation Guide for Minimum Retroreflectivity Requirements for Traffic Signs*. FHWA-RD-97-052, Federal Highway Administration, Washington, D.C., 1998.
3. Carlson, P.J. and H.G. Hawkins. *Updated Minimum Retroreflectivity Levels for Traffic Signs*. FHWA-RD-03-081, Federal Highway Administration, Washington, D.C., 2003.
4. Carlson, P.J., H.G. Hawkins, G.F. Schertz, K.S. Opiela, and D.J. Mace. Developing Updated Minimum In-Service Retroreflectivity Levels for Traffic Signs, In *Transportation Research Record 1824*, Transportation Research Board, Washington, D.C., 2003.