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 FHWA

Peter J. Hatzi, 202-366-8036

U.S. Department of Transportation
Federal Highway Administration

Maintaining Traffic Sign Retroreflectivity

FHWA-SA-03-027 December 2003

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

The concept of visibility encompasses many different considerations and is difficult to quantify as an overall measure. Specific metrics such as conspicuity, legibility, or retroreflectivity are used to represent the various elements that contribute to visibility. Conspicuity is the ability to identify a target (such as a sign) from its surroundings. It is what helps the user to first see a sign. Legibility is the ability to identify the message (content) of the target. It is what helps the user to read the sign.

The nighttime environment presents many sign visibility challenges. At night, road users cannot see as many visual cues as they can in the day. This places greater reliance on signs and other traffic control devices. To provide nighttime sign visibility, most signs are made from retroreflective sheeting. Retroreflectivity is the property of a material to redirect light back toward the originating source. It is what helps make a sign conspicuous and legible.

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

Sign location and orientation also impact sign visibility. Signs placed outside of the driver's cone of vision may not be seen by the driver even though they meet other visibility criteria. Likewise, signs behind obstructions (such as a structure or vegetation) may meet some visibility criteria, but can't 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 recommendations and general information about minimum maintained retroreflectivity levels and the methods that can be used to maintain sign retroreflectivity. Information contained in this document is intended for policymakers and managers. A separate FHWA document (available in 2004) provides technical details about the various methods to maintain sign retroreflectivity.

RETROREFLECTIVITY MAINTENANCE

There are several methods that agencies can use to maintain sign retroreflectivity above the minimum maintained retroreflectivity levels that FHWA has developed through research. These minimum retroreflectivity levels 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 agencies need to measure the retroreflectivity of every sign in their jurisdictions. Instead, these methods provide agencies with options that will help

to improve nighttime sign visibility.

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 signs. The FHWA has identified several assessment and management methods for maintaining sign retroreflectivity in a manner that is consistent with the 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

In the visual nighttime inspection method, agency personnel assess the nighttime visibility of their signs. The visual inspection method is probably the most consistent with current practices at many agencies. Visual inspections are also recommended in Section 2A.22 of MUTCD.

In the visual inspection method, the inspector assesses the visibility and retroreflectivity of the traffic signs as he/she approaches the signs. Signs need to be replaced if they do not meet the comparison defined in the appropriate procedure. The following recommendations provide general guidance on how to conduct 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. If it is necessary to slow or stop the vehicle to read the sign, the sign typically needs to be replaced. Signs are normally inspected from the travel lane.
- The inspection is conducted using the low beam headlights. It is better not to use the bright beams for inspections as they create higher illuminance levels at the sign and make it appear brighter than it would to a driver using low beams.
- 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 above, one or more of the following procedures are used in conducting visual nighttime inspections.

Calibration Signs Procedure

Calibration signs are viewed prior to conducting the nighttime inspection. The calibration signs have retroreflectivity levels at or above the minimum levels. These signs are set up where the inspectors can view the calibration signs in a manner similar to how they will conduct the nighttime inspection. 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 levels.
- The calibration signs are viewed at typical viewing distances and from the same vehicle that will be used for conducting the 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 is checked at periodic intervals to ensure that the calibration panels have the appropriate retroreflectivity levels.
- Field signs need to be replaced if the inspector judges a sign to be less bright than the appropriate calibration sign. Consistent Parameters Procedure

The same factors that were used to develop the minimum levels are 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 age 60 or older.
- Signs are viewed at the typical viewing distance for that sign.
- Signs need to be replaced if they are not legible to the inspector.

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 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. If the comparison panel appears brighter than the sign, the sign needs to be replaced.

Measured Retroreflectivity Method

In this method, the retroreflectivity of a sign is measured and directly compared to the minimum level appropriate to that sign. If the sign retroreflectivity is lower than the minimum levels, the sign needs to be replaced. The following factors provide additional information about measuring sign retroreflectivity:

- ASTM E1709, Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflectometer, provides a standard method for measuring sign retroreflectivity using a handheld retroreflectometer.
- A sign needs to be replaced if the average retroreflectivity value is

less than the appropriate minimum level.

MANAGEMENT METHODS

The management methods provide an agency with the ability to maintain sign retroreflectivity without having to devote significant effort into assessing 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 the minimum retroreflectivity levels. The following factors provide additional information about using this method:

- The expected service life of a sign can be based on several different sources of information, such as:
  - Sign sheeting warranties.
  - Sign test deck measurements.
  - Measurements of actual signs.
- An agency will need a method of identifying the age of individual signs. Potential methods include:
  - A sticker or other label attached to the sign that identifies the year of fabrication, installation, or replacement.
  - A sign management system that can identify the age of individual signs.

Blanket Replacement Method

In this method, an agency replaces all the signs in an area/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. The following factors provide additional information about the use of this procedure:

- 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/corridor/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. The following factors provide additional information about using this method:

- An agency develops a sampling plan to determine the appropriate number of control signs needed to represent the agency's sign population.
- Control signs may be actual signs in the field or 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 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 may want to consider the interval before the next assessment or management event as part of the sign evaluation and replacement process. In some cases, it may 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/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.
- All signs with blue or brown backgrounds.
- Bikeways which are not immediately adjacent to a roadway and that are intended for exclusive use by bicyclists and/or pedestrians.

MINIMUM RETROREFLECTIVITY LEVELS

Since the early 1990s, the FHWA has sponsored several different efforts to develop research recommendations for minimum retroreflectivity levels for traffic signs. These efforts represent various attempts to define and refine the concept of minimum maintained sign retroreflectivity. Initial minimum retroreflectivity levels were developed through research in 1993 (1). These levels were revised in 1998 through further research (2). Updated minimum levels were developed in 2003 (3) and are the ones that FHWA proposes for use. A paper describes the evolution of the research to develop minimum levels of sign retroreflectivity (4).

The updated minimum levels of sign retroreflectivity are generally similar in magnitude to levels published previously, but represent several refinements and updates. The following improvements were incorporated into the 2003 updated levels:

- An improved computer model was used to develop the minimum levels.
- Additional sheeting types 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 pick-up trucks.
- The luminance level needed for legibility was increased to better accommodate older drivers.
- Minimum retroreflectivity levels were consolidated across more sheeting types to reduce the number of minimum levels.

The updated minimum maintained retroreflectivity levels are shown in the adjacent table. They represent the most current research recommendations, and are recommended by FHWA, but are limited to the current knowledge of the nighttime luminance requirements of traffic signs. The assumptions and limitations associated with the development of these levels are described in the research report (3). It should be noted that there may be situations where, based on engineering judgment, an agency may want to provide greater retroreflectivity.

Minimum Maintained Retroreflectivity Levels

Sign Color	Criteria	Sheeting Type (ASTM D4956-01a)					
		I	II	III	VII	VIII	IX
White on Red	See Note ①	35//7					
Black on Orange or Yellow	See Note ②	*	50				
	See Note ③	*	75				
Black on White	—	50					
White on Green	Overhead	*//7	*//15	*//25	250//25		
	Shoulder	*//7	120//15				

NOTES:
Levels in cells represent legend retroreflectivity // background retroreflectivity (for positive contrast signs). Units are cd/lx/m^2 measured at an observation angle of 0.2 and an entrance angle of -4.0 .
① Minimum Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity).
② For text signs measuring 48 inches or more and all bold symbol signs.
③ For text signs measuring less than 48 inches and all fine symbol signs.
* Sheeting type should not be used.

Bold Symbol Signs	W1-1 – Turn W1-2 – Curve W1-3 – Reverse Turn W1-4 – Reverse Curve W1-5 – Winding Road W1-6 – Large Single Arrow W1-7 – Large Double Arrow W1-8 – Chevron W1-9 – Turn & Advisory Speed W1-10 – Horizontal Alignment & Intersection W2-1 – Cross Road W2-2, W2-3 – Side Road W2-4 – T Intersection W2-5 – Y Intersection W2-6 – Circular Intersection W3-1a – Stop Ahead W3-2a – Yield Ahead W3-3 – Signal Ahead W4-3 – Added Lane W6-1 – Divided Highway Begins W6-2 – Divided Highway Ends W6-3 – Two-Way Traffic W10-1, -2, -3, -4 – Highway-Railroad Intersection Advance Warning W11-2 – Pedestrian Crossing W11-3 – Deer Crossing W11-4 – Cattle Crossing W11-5 – Farm Equipment W11-5p, -6p, -7p – Pointing Arrow Plaques W11-8 – Fire Station W11-10 – Truck Crossing W12-1 – Double Arrow
Fine Symbol Signs	All symbol signs not listed in the bold category are considered fine symbol signs.
Special Case Signs (for requirements in addition to yellow color addressed in above table)	W3-1a – Stop Ahead o Red retroreflectivity ≥ 7 W3-2a – Yield Ahead o Red retroreflectivity ≥ 7, White retroreflectivity ≥ 35 W3-3 – Signal Ahead o Red retroreflectivity ≥ 7, Green retroreflectivity ≥ 7 W14-3 – No Passing Zone, W4-4p – Cross Traffic Does Not Stop, or W13-2, -3, -1, -5 – Ramp & Curve Speed Advisory Plaques o Use largest sign dimension to find proper category in above table

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, accepted for publication in the Transportation Research Record, Transportation Research Board, Washington, D.C., 2003.