# Traffic Sign Retroreflectivity Workshop


**July 12, 2011**

texite
Greater Dallas Section

# Traffic Sign Retroreflectivity


Basics of Sign Retroreflectivity & New Sign Maintenance Requirements



# Today's Speaker

- Paul J Carlson, PhD, PE
  - Texas Transportation Institute, Texas A&M University
    - Research Engineer
    - Head – Operations & Roadway Safety Division
  - Member of FHWA Retroreflectivity Team
  - Member:
    - ASTM, TRB, NCUTCD, ITE



# Today's Schedule

| Start Time | Stop Time | Description |
|---|---|---|
| 9:30 | 10:00 | Check in / Registration |
| 10:00 | 10:15 | Welcome / Participant Introductions |
| 10:15 | 10:45 | Basic Retroreflectivity / Nightime Visibility Concepts |
| 10:45 | 11:05 | Texas MUTCD Requirements and compliance dates |
| 11:05 | 11:45 | Sign Retro Maintenance Methods |
| 11:45 | 12:15 | LUNCH |
| 12:15 | 12:45 | Retroreflectometer Demo / Discussions |
| 12:45 | 2:00 | Open Floor Discussions:<br>- Practical Implementation of new requirements<br>- Life Cycle Costs and cost reduction<br>- Around the room, what have you already implemented, what are you still planning, how well is it working, and what does it cost?<br>- Other items? |

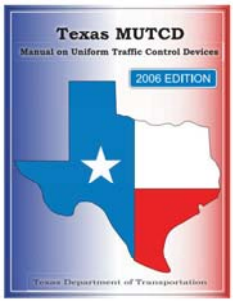


# Welcome

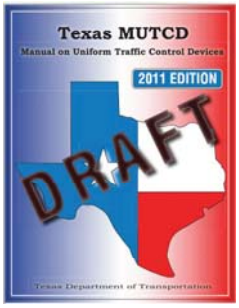
- **Retroreflectivity is important!**
- Importance has increased
- Not a part of any educational curriculum
  - "OTJ" training
- Your agency is now responsible to maintain sign retroreflectivity



# Texas MUTCDs



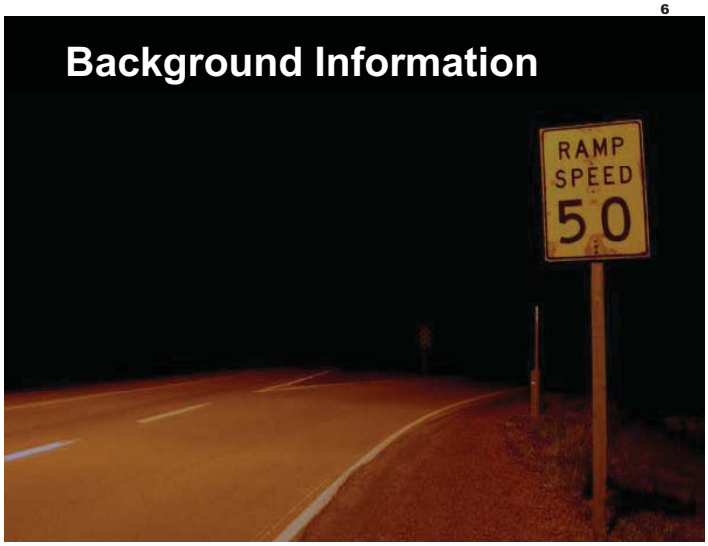

Current TX MUTCD




http://www.txdot.gov/



# Background Information



# Why Do We Install Signs?

***Required by MUTCD?***

***NO***

***Engineering Decision?***

***YES!***

***Why?***

***To help drivers***
***(including older)***




# Key Issue: Older Drivers

- 10.7 million drivers age 70+ in 1990
- 20.6 million drivers age 70+ in 2006
  - 48% increase from 1990 to 2006
    - 1990 — 8% of drivers were 70+
    - 2006 — 10.2% of drivers were 70+
- "Older" driver population will continue to grow as baby-boomers age



# TMUTCD – Existing Reqs.

- Texas Manual on Uniform Traffic Control Devices
- Section 2A.06 – Design of Signs
  - The basic requirements of a highway sign are that it be legible to those for whom it is intended and that it be understandable in time to permit a proper response. Desirable attributes include:
    - High visibility by day and night; and
    - High legibility (adequately sized letters or symbols, and a short legend for quick comprehension by a road user approaching a sign).



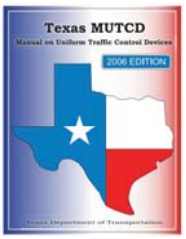
# TMUTCD Sign Maintenance

**TMUTCD Section 2A.22 Maintenance**

Maintenance activities should consider proper position, cleanliness, legibility, and daytime and nighttime visibility (see Section 2A.09). Damaged or deteriorated signs should be replaced.

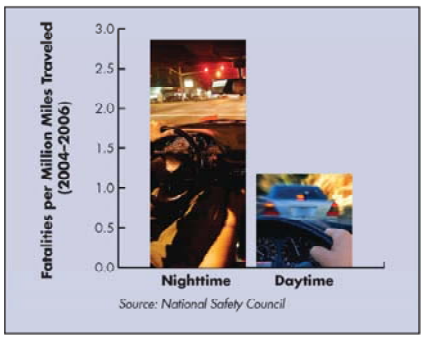
To assure adequate maintenance, a schedule for inspecting (both day and night), cleaning, and replacing signs should be established.

Steps should be taken to see that weeds, trees, shrubbery, and construction, maintenance, and utility materials and equipment do not obscure the face of any sign.






# Night Travel and Crashes

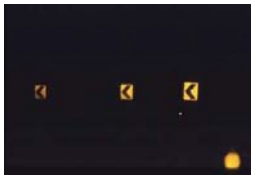





# Nighttime Driving

**Daytime**
**Many cues available**
**Driver task relatively easy**

**Nighttime**
**Few cues remain**
**Task more difficult**



***Retroreflectivity provides nighttime guidance***

## Why Create Minimums?

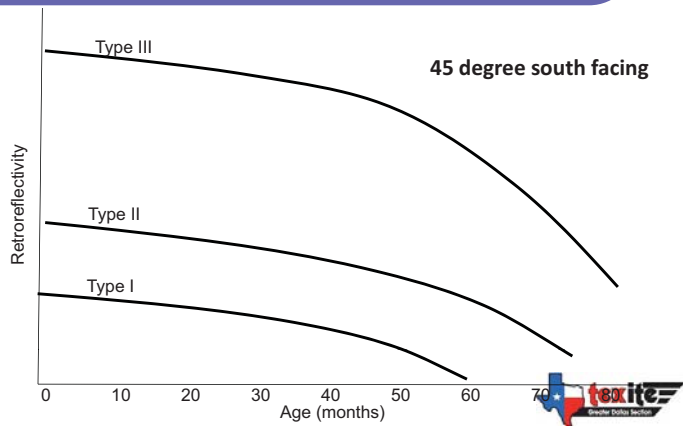
Daytime



Nighttime



## Typical Outdoor Durability Testing

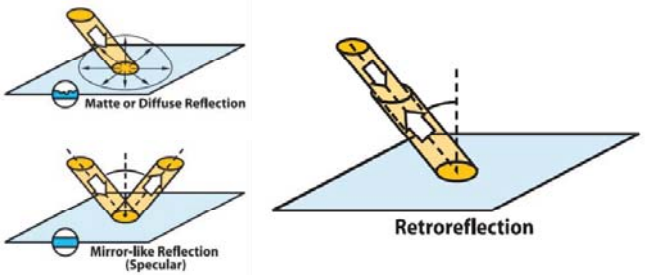





## Retroreflectivity Concepts



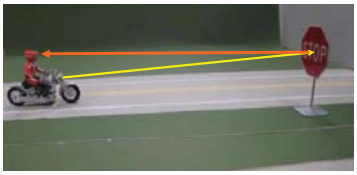

## RETROreflection






## Retroreflection
### Informal Definition

- A ratio of the amount of light returned from a sign versus the amount hitting the sign
- A way to measure the efficiency of a material

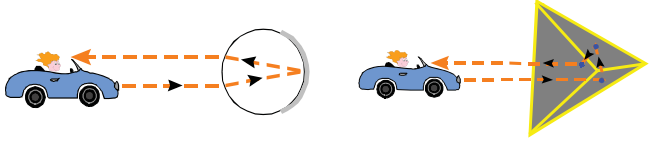


$$\frac{\text{Light } \textbf{OUT} \text{ of sign}}{\text{Light } \textbf{INTO} \text{ sign}} = \textbf{Retroreflectivity}$$



## Retroreflective Elements

- Glass spheres and microsized prisms are the current technologies used to make sign materials retroreflective

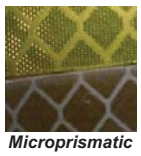


- The light is returned to the source in a cone shaped pattern

# Sign Sheeting Materials

*Engineering Grade*

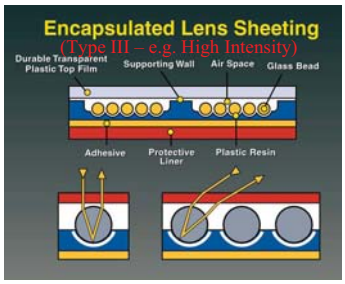
*Hi-Intensity Beaded*

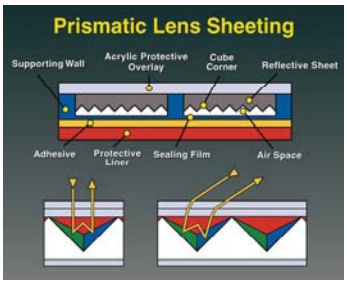


*Microprismatic*



# Sheeting Types



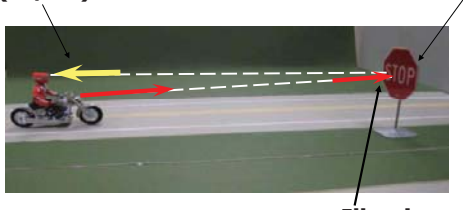






# Technical Terms

**Luminance** (*cd/m²*)

***Retroreflective Sign*** (*$R_A$ cd/lx/m²*)




**Illuminance** (*lx*)

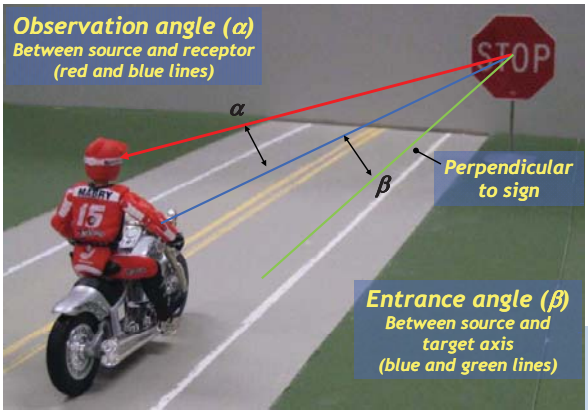


# Basic Angles of Retroreflectivity

- Observation Angle – Where in the cone is the measurement made (from the light source).
- Entrance Angle – What is the orientation of the sign or pavement marking (is from the light source)



# Key Geometry Angles






# Sheeting Specification Geometry

- Example: ASTM D4956

TABLE 8 Type III Sheeting[A]

| Observation Angle | Entrance Angle | White | Yellow | Orange | Green | Red | Blue | Brown |
|---|---|---|---|---|---|---|---|---|
| 0.1°[B] | –4° | 300 | 200 | 120 | 54 | 54 | 24 | 14 |
| 0.1°[B] | +30° | 180 | 120 | 72 | 32 | 32 | 14 | 10 |
| 0.2° | –4° | 250 | 170 | 100 | 45 | 45 | 20 | 12 |
| 0.2° | +30° | 150 | 100 | 60 | 25 | 25 | 11 | 8.5 |
| 0.5° | –4° | 95 | 62 | 30 | 15 | 15 | 7.5 | 5.0 |
| 0.5° | +30° | 65 | 45 | 25 | 10 | 10 | 5.0 | 3.5 |

[A] Minimum Coefficient of Retroreflection ($R_A$) cd/fc/ft²(cd·lx⁻¹·m⁻²).
[B] Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

## Rotational Sensitivity

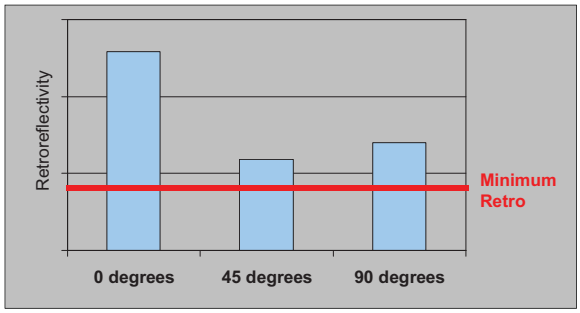



## Rotation Marks

- Microprismatic sheeting
  - Retroreflectivity can vary with rotation
- Some prismatic sheeting has orientation arrows
- Arrows used for measuring, cutting, and fabricating signs

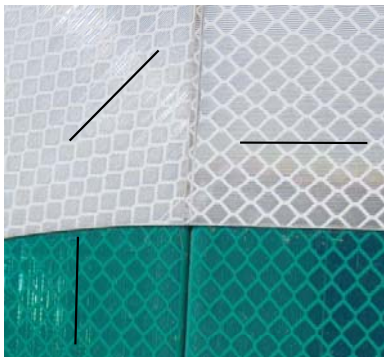


## Rotational Sensitivity






## Sheeting Orientation





## Questions



## MUTCD Sign Retroreflectivity Maintenance Requirements

New Requirements

# Congressional Legislation

**1993 DOT Appropriations Act**

**"The Secretary of Transportation shall revise the MUTCD to include a standard for a minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings which apply to all roads open to public travel."**



# Final Rule

Federal Register

- Published on Dec 21, 2007
  - Vol 72, No. 245
- Revision #2 of the 2003 Edition of the MUTCD
- Effective Jan 22, 2008



## New MUTCD Language
Section 2A.09 Maintaining Minimum Retroreflectivity

- "Standard:

  Public agencies or officials having jurisdiction shall use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels in Table 2A-3"



## New MUTCD Language
Section 2A.09 Maintaining Minimum Retroreflectivity

- "Support:

  Compliance… is achieved by having a method in place and using the method to maintain the minimum levels established in Table 2A-3. Provided that… a method is being used, an agency would be in compliance… even if there are some individual signs that do not meet the… levels at a particular point in time.



# New MUTCD Language

**"…One or more of the following assessment or management methods should be used…"**

- Visual Nighttime Inspection
  - Calibration Signs
  - Comparison Panels
  - Consistent Parameters
- Measured Sign Retro
- Expected Sign Life
- Blanket Replacement
- Control Signs
- Future Method Based On Engr. Study
- Combination Of Any

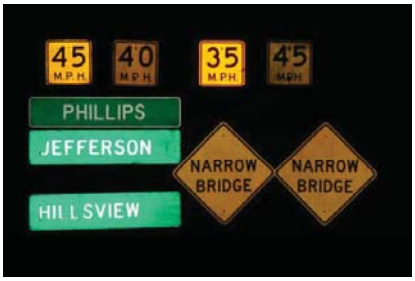


## New MUTCD Table 2A.3
## Minimum Maintained Retroreflectivity Levels

| Sign Color | Sheeting Type (ASTM D4956-04) ① | | | | 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 | | | | — |

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°.
②For text and fine symbol signs measuring at least 1200 mm (48 in) and for all sizes of bold symbol signs
③For text and fine symbol signs measuring less than 1200 mm (48 in)
④Minimum Sign Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)
* This sheeting type should not be used for this color for this application.

## What do the numbers look like?




*Pictures do not represent retroreflectivity well*



## Exempt Signs

- Parking/Standing/Stopping
- Walking/Hitchhiking
- Adopt-A-Highway
- Blue or Brown Backgrounds
- Exclusive Use of Bikes or Peds

Note: Must still meet other requirements in MUTCD (inspections, retroreflective, etc,)




## Clarification

- Fluorescent colors
  - fluorescent yellow -- > yellow
  - fluorescent yellow-green -- > yellow
  - fluorescent orange -- > orange



## Compliance Dates

- **Establish and implement method(s)**
  - **January, 2012**
- **Replace identified regulatory, warning, ground-mounted guide signs (except street-name)**
  - January, 2015
- **Replace identified street name & overhead guide signs**
  - January, 2018



## Summary of New Language

- Public agencies or officials having jurisdiction shall use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels in Table 2A-3"
- Compliance… is achieved by having a method in place and using the method to maintain the minimum levels established in Table 2A-3. Provided that… a method is being used, an agency would be in compliance… even if there are some individual signs that do not meet the… levels at a particular point in time.



## Can you see the sign?

## Questions



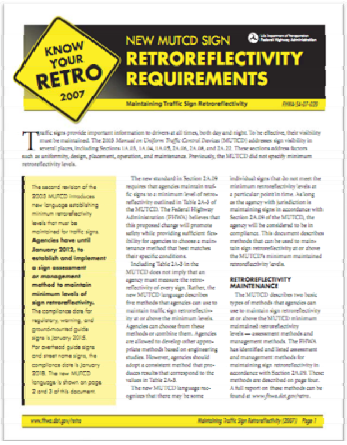
## MUTCD Sign Maintenance Methods



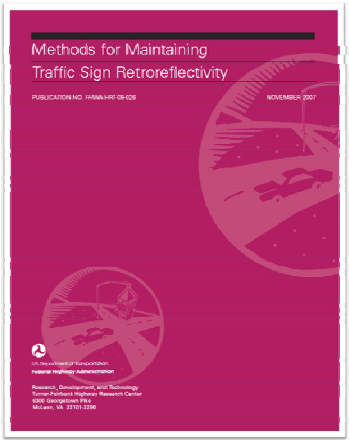

## Can we decide to replace signs based on daytime inspections?




**FHWA-SA-07-020**




**FHWA-HRT-08-026**






## MUTCD Methods

- Visual assessment
- Measured retroreflectivity
- Expected sign life
- Blanket replacement
- Control signs
- Future methods
- Combination of methods


www.fhwa.dot.gov/retro



## Method: Visual Assessment

**3 Techniques:**

- Comparison panels procedure, or
- Calibration signs procedure, or
- Consistent parameter procedure

## Method: Visual Assessment

- Tie to minimum values with comparison panels
  - Panels are near desired retro
  - Clipped to sign - viewed from distance
  - Evaluate signs compared to panels




## Comparison Panels

- Comparison panels must have a retroreflectivity level at least that designated in the MUTCD
- The procedure must be done at night


These panels have retroreflectivity levels at the levels in the MUTCD minimum retroreflectivity table





## Source of Comparison Panels

- With a retroreflectometer, an agency can find in-service signs near the minimum levels. These signs can be removed from service and cut into smaller pieces.
- An agency can also look through their scrap yard.
- Avery Dennison just announced availability comparison panels.





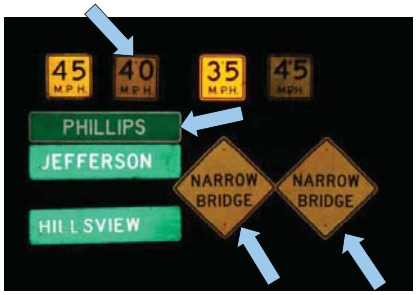
## Field Procedure





## Method: Visual Assessment

- "Calibrate" eyes with calibration signs
- Calibration signs are near minimum retro
- Evaluate signs compared to calibration signs






## Calibration Signs

- Calibration signs must have a retroreflectivity level at least that designated in the MUTCD
- The inspection has to be done at night

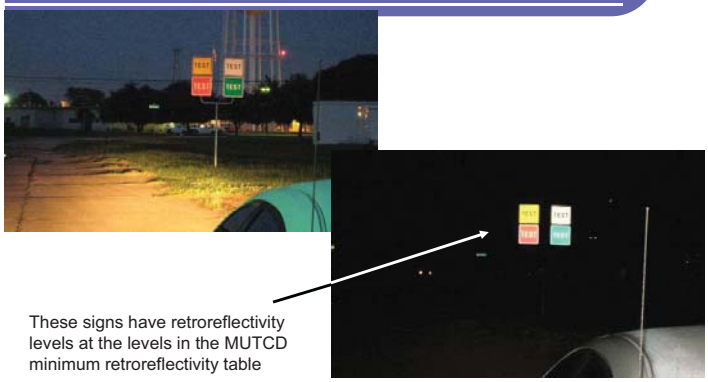
## Source of Calibration Signs

- With a retroreflectometer, an agency can find in-service signs near the minimum levels. These signs can be removed from service and stored until nighttime sign inspections commence.
- An agency can also look through their scrap yard for representative signs.
- Avery Dennison just announced availability comparison panels.





## Field Procedure



These signs have retroreflectivity levels at the levels in the MUTCD minimum retroreflectivity table





## Visual Inspection Method: Consistent Parameter Procedure



## Overview

- With this method, a SUV or truck has to be used with specific headlamps (described later) and the inspector needs to be at least 60 years old.
- The inspection occurs at highway speeds.
- No calibration signs or comparison panels are needed.
- This method simulates the conditions of the research which FHWA used as a foundation for the minimum retroreflectivity levels.





## Field Technique

- Preferable to use a two person crew.
- Must have a SUV, pick-up, or similar vehicle with VOA style headlamps.
- Driver can be any age but inspector needs to be at least 60 years old.
- Inspection occurs at highway speeds.
- Inspector concentrates on judging sign retroreflectivity.
  - Example: adequate, marginal, poor (replace)
- Driver concentrates on driving safely.





## Method: Measure Sign Retro

- Use a portable instrument
- Receive proper training
- Have a protocol for consistency
- Compare readings to minimum values

## Overview

- This method includes sign retroreflectivity measurements of in-service signs
- The measurements are made with devices similar to cordless drills
- The measurement devices must be in contact with the sign face
- **The measurements need to be periodically repeated (e.g., annually or every other year)**



## Examples of Sign Retroreflectometers

Contact Devices:

*Model 922 (Gamma Scientific)*

*Model GR3 (Delta)*

Non-Contact Devices:

***SMARTS Van***

Experimental concept, but NOT yet available.



## Field Procedure

- Make note of the type of sheeting
- Measure each color that is retroreflective
- Multiple measurements should be made to compute an average
- A measurement protocol should be developed
- An extension pole or ladder will be needed



**FHWA Retroreflective Sheeting Identification Guide – September 2005**

**Notes:** ASTM Types are shown as stated by the manufacturers using ASTM D4956-04 "type" designations.
Agencies should verify that the sheeting they use complies with their specifications or ASTM D4956.
FHWA does not endorse or approve any material nor does it determine type category(s) for materials.
This side of the Sheeting ID Guide is for rigid surfaces only. The other side is for flexible surfaces and non-signing applications.

**Retroreflective Sheeting Materials for Rigid Sign Surfaces Made with Glass Beads**

| Example of Sheeting (Shown to scale) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ASTM Type | I | II | II | III | III | III | III | III | III |
| Manufacturer | See note A | Avery Dennison® | Nippon Carbide | 3M™ | ATSM, Inc. | Avery Dennison® | Kiwalite® | LG Lite | Nippon Carbide |
| Brand Name | Engineer Grade | Super Engineer Grade | Super Engineer Grade | High Intensity | High Intensity | High Intensity | High Intensity | High Intensity | High Intensity |
| Series Number | Several | T-2000 | 15000 17000 18000 | 2800 3800 | ASTM HI | T-5500 | 22000 | LH8000 LH8100 | N500 N800 |
| NOTES: | A | | | | | | | | |

**Retroreflective Sheeting Materials for Rigid Sign Surfaces Made with Prisms**

| Example of Sheeting (Shown to scale) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ASTM Type | III, IV | III, IV, X | VII, VIII, X | VIII | IV, VIII | IX | IX | X | Unassigned |
| Manufacturer | Avery Dennison® | 3M™ | 3M™ | Avery Dennison® | Nippon Carbide | 3M™ | Avery Dennison® | Nippon Carbide | 3M™ |
| Brand Name | High Intensity Prismatic | High Intensity Prismatic | Diamond Grade™ LDP | MVP Prismatic | Crystal Grade | Diamond Grade™ VIP | Omni-View™ | Crystal Grade | Diamond Grade™ DG3 |
| Series Number | T-6500 | 3930 | 3970 | T-7500 | 94000 (IV) 92000 (VIII) | 3990 | T-9500 | 93000 | 4000 |
| NOTES: | B | B | B,D | | B,C | | | C | |

A – All the manufacturers listed on the other side of this guide (except Reflexite) provide Engineer Grade sheeting. Engineer Grade sheeting is uniform without any patterns or identifying marks. Visually, it is indistinguishable from lower quality grades (i.e., utility and commercial grades).
B – These materials can be classified as different ASTM Types.
C – These materials are visually indistinguishable from one another.
D – The arrow or "water mark" on this product is no longer included with new productions.



## Measurement Protocol
### Example


- For Stop signs, an agency may require a minimum of 4 measurements per color as shown to the left
- The average of the 4 measurements would be used to assess the condition of the sign retroreflectivity



## Taking Measurements

# Method: Expected Sign Life

- Find the life of the sheeting type in your area
- Replacement based on expected life for individual signs



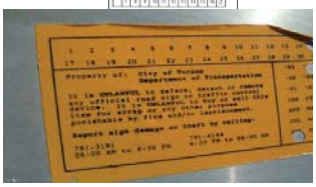


# Indicating Sign Age

- Stickers on front or back of sign to show when fabricated or installed









# Determining Sign Life

- Build and use a weathering rack like the one shown
- Use AASHTO-NTPEP data
- Use warranty information from sheeting company
- Specify sign life
- Measure existing signs with known install date and compare to min level
- Use weathering data or nearby jurisdiction's weathering data

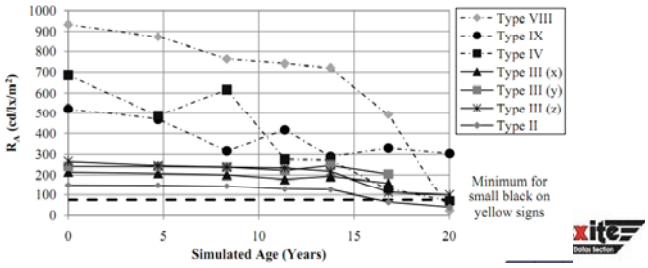


# Using Warranty Information

- Predicted sign age could be provided in a warranty by sheeting manufacturers.
- Typical warranties not typically based on minimum retroreflectivity levels
- Agencies could develop specifications with warranties based on minimum retroreflectivity levels
  - Example: Warranty Type III sheeting for 15 years in accordance to Table 2A-3 of the MUTCD



# Weathering Racks at TTI



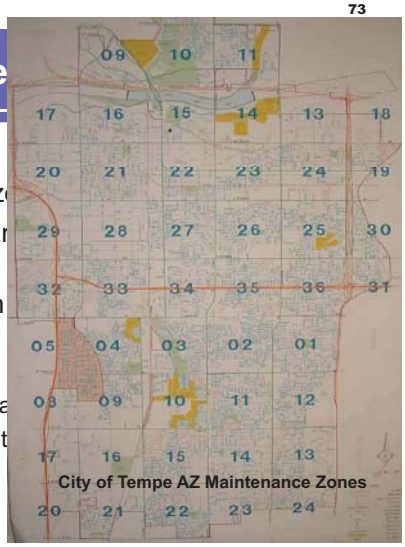



# Method: Blanket Replacement

- All signs in an area/corridor are replaced at the same time at specified intervals
- Specified intervals could be set based on expected sign life
- Some existing blanket sign replacement policies exist using 10-12 years for Beaded High-Intensity sheeting signs

## Blanket Replace

- Divide agency into areas/corridors or z
- Relate number of ar replacement cycle
- Replace all signs in area/ corridor each replacement cycle
  - 10 yr life, ➔ 10 area
  - Annual replacement area






## Method: Control Signs

- Sign life is estimated using a subset of signs representing an agency's inventory.
  - Subset of signs is the "control signs"
- Control signs can be in-service signs or signs in a maintenance yard.
- Agency monitors control signs to estimate condition of all their signs.
- Periodically measure retroreflectivity of control signs.

***Example of Control Signs***




## MUTCD Methods

- Visual assessment
- Measured retroreflectivity
- Expected sign life
- Blanket replacement
- Control signs
- Future methods
- Combination of methods

www.fhwa.dot.gov/retro



## Method: Other Options

- Flexibility is provided for future advancements in technology and methods that have not been fully developed
- Must be based on an engineering study




## Future Technologies

- Mobile sign retroreflective measurement technology being developed by at least 3 different companies
- Similar to existing process that measures pavement marking retroreflectivity at highway speeds



## MUTCD Methods

- Visual assessment
- Measured retroreflectivity
- Expected sign life
- Blanket replacement
- Control signs
- Future methods
- Combination of methods

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# NCHRP Survey Participants

Survey conducted May 2011


Included 9 cities, 15 counties, 16 DOTs, and 9 others



# Agency Method Selection

| MUTCD Methods | Primary Sign Replacement Method | Secondary or Support Method |
|---|---|---|
| Nighttime Inspection | 13 | 2 |
| Measured Retro. | 2 | 0 |
| Expected Sign Life | 17 | 16 |
| Blanket Replacement | 7 | 4 |
| Control Signs | 2 | 10 |

Note: Table only includes agencies that operate and maintain roadways that are open to the public

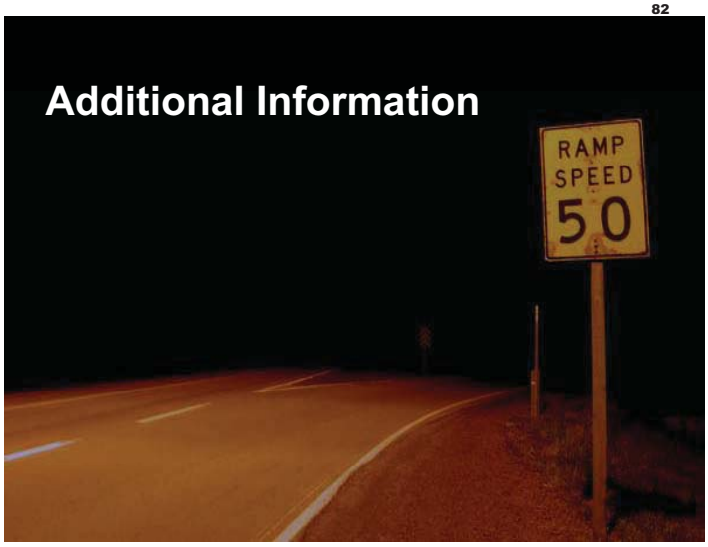


# Summary: Methods Allowed

- Visual Nighttime Inspection
  - Calibration Signs
  - Comparison Panels
  - Consistent Parameters
- Measured Sign Retro
- Expected Sign Life
- Blanket Replacement
- Control Signs
- Future Method Based On Engr. Study
- Combination Of Any



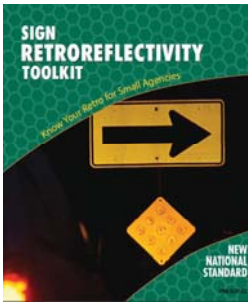
# Additional Information






# More Information

- ATSSA www.retroreflectivity.net
  - Primer on retroreflectivity
  - Common questions
- FHWA fhwa.dot.gov/retro
  - Summary Brochure
  - Final Rule
  - Power Point Presentations
  - Newsletter Articles
  - Frequently Asked Questions






# FHWA Supporting Material


- FHWA Retro Web Site
  *www.fhwa.dot.gov/retro*
- 4-page summary
- FAQs
- Research Reports

## FHWA Retroreflective Sheeting Identification Guide – September 2005

**Notes:** ASTM Types are shown as stated by the manufacturers using ASTM D4956-04 "type" designations.
Agencies should verify that the sheeting they use complies with their specifications or ASTM D4956.
FHWA does not endorse or approve any material nor does it determine type category(s) for materials.
This side of the Sheeting ID Guide is for rigid surfaces only. The other side is for flexible surfaces and non-signing applications.

**Retroreflective Sheeting Materials for Rigid Sign Surfaces Made with Glass Beads**

| Example of Sheeting (Shown to scale) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ASTM Type | I | II | II | III | III | III | III | III | III |
| Manufacturer | See note A | Avery Dennison® | Nippon Carbide | 3M™ | ATSM, Inc. | Avery Dennison® | Kiwalite® | LG Lite | Nippon Carbide |
| Brand Name | Engineer Grade | Super Engineer Grade | Super Engineer Grade | High Intensity | High Intensity | High Intensity | High Intensity | High Intensity | High Intensity |
| Series Number | Several | T-2000 | 15000 17000 18000 | 2800 3800 | ASTM HI | T-5500 | 22000 | LH8000 LH8100 | N500 N800 |
| NOTES: | A | | | | | | | | |

**Retroreflective Sheeting Materials for Rigid Sign Surfaces Made with Prisms**

| Example of Sheeting (Shown to scale) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ASTM Type | III, IV | III, IV, X | VII, VIII, X | VIII | IV, VIII | IX | IX | X | Unassigned |
| Manufacturer | Avery Dennison® | 3M™ | 3M™ | Avery Dennison® | Nippon Carbide | 3M™ | Avery Dennison® | Nippon Carbide | 3M™ |
| Brand Name | High Intensity Prismatic | High Intensity Prismatic | Diamond Grade™ LDP | MVP Prismatic | Crystal Grade | Diamond Grade™ VIP | Omni-View™ | Crystal Grade | Diamond Grade™ DG3 |
| Series Number | T-6500 | 3930 | 3970 | T-7500 | 94000 (IV) 92000 (VIII) | 3990 | T-9500 | 93000 | 4000 |
| NOTES: | B | B | B,D | | B,C | | | C | |

A – All the manufacturers listed on the other side of this guide (except Reflexite) provide Engineer Grade sheeting. Engineer Grade sheeting is uniform without any patterns or identifying marks. Visually, it is indistinguishable from lower quality grades (i.e., utility and commercial grades).
B – These materials can be classified as different ASTM Types.
C – These materials are visually indistinguishable from one another.
D – The arrow or "water mark" on this product is no longer included with new productions.



# Thank You

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