TRB Webinar

Signs and Pavement Marking Retroreflectivity – Measurement Basics, Safety Benefits, Advancements: A State Department of Transportation (DOT) Perspective
Sign retroreflectivity levels will vary
New signs can have different retroreflectivity levels and different degradation rates over time.
Sign Retroreflectivity Specifications

ASTM E 1709 Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflectometer

Coefficient of Retroreflection, $R_A$ – the ratio of the coefficient of luminous intensity of a plane retroreflecting surface to its area expressed in candelas per lux per square meter. (cd/lx/m²)
Sign Sheeting Types

**Encapsulated Lens Sheeting**  
(Type III – e.g. High Intensity)

- Durable Transparent Plastic Top Film
- Supporting Wall
- Air Space
- Glass Bead
- Adhesive
- Protective Liner
- Plastic Resin

**Prismatic Lens Sheeting**

- Supporting Wall
- Acrylic Protective Overlay
- Cube Corner
- Reflective Sheet
- Adhesive
- Protective Liner
- Sealing Film
- Air Space
Basic Angles of Ground-Mounted Sign Retroreflectivity

**Observation angle**

**Entrance angle Of Sign**
Portable Retroreflectometers – Different Types

Point Instrument - has a single light detector next to the light source or axis and makes an $R_A$ measurement virtually identical to an $R_A$ measurement made on a lab range system where the light detector is on top of the light source. Like the motorcycle illustration. Typical $R_A$ specifications require making measurements at 0 and 90 degree orientations and averaging the two values.

Annular Instrument – has a circular light detector positioned around the light axis and makes an $R_A$ measurement similar to an average of several $R_A$ measurements on a range system or point instrument. No averaging needed.

Variability of Sign Sheeting $R_A$ at 0 and 90 Degree Orientation – some sheeting shows greater than 20% difference in $R_A$ at 0 and 90 degree orientations.
Point Instrument –
0 Degree Measurement
Point Instrument –
90 Degree Measurement
Calibrating the Instrument with Sheeting Standard = 321
Example of testing a Quality Control sample. (Low retro value).
Example of testing a Quality Control sample.
(High retro value).
When testing sign legend, the aperture size may need to be reduced.
If aperture size is changed, you should recalibrate instrument!
Challenges of making portable instrument measurements

Sign Access

Sign Cleaning?
Challenges in making retroreflective measurements of road signs using portable instruments:

1. Understanding the correct use of the instrument.
   - Correct training is critical.
   - Charging, battery life, calibrations, aperture changes and recalibration and QC checks.

2. Gaining access to road signs
   - Ladders, instrument extensions, safety

3. When to clean signs. Normally we don’t recommend cleaning signs unless they are very dirty.

4. Making measurements of the sheeting — background and legend. Test in several locations and average the results.

5. Documenting sign location, sheeting type, and test results.
<table>
<thead>
<tr>
<th>Observation Angle</th>
<th>Entrance Angle</th>
<th>White</th>
<th>Yellow</th>
<th>Orange</th>
<th>Green</th>
<th>Red</th>
<th>Blue</th>
<th>Brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1°&lt;sup&gt;B&lt;/sup&gt;</td>
<td>−4°</td>
<td>300</td>
<td>200</td>
<td>120</td>
<td>54</td>
<td>54</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>0.1°&lt;sup&gt;B&lt;/sup&gt;</td>
<td>+30°</td>
<td>180</td>
<td>120</td>
<td>72</td>
<td>32</td>
<td>32</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>0.2°</td>
<td>−4°</td>
<td>250</td>
<td>170</td>
<td>100</td>
<td>45</td>
<td>45</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>0.2°</td>
<td>+30°</td>
<td>150</td>
<td>100</td>
<td>60</td>
<td>25</td>
<td>25</td>
<td>11</td>
<td>8.5</td>
</tr>
<tr>
<td>0.5°</td>
<td>−4°</td>
<td>95</td>
<td>62</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>7.5</td>
<td>5.0</td>
</tr>
<tr>
<td>0.5°</td>
<td>+30°</td>
<td>65</td>
<td>45</td>
<td>25</td>
<td>10</td>
<td>10</td>
<td>5.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>

<sup>A</sup> Minimum Coefficient of Retroreflection \((R_A)\) cd/£c/£t²(cd£x⁻¹£m⁻²).
Portable Retroreflectometers

Delta
Retrosign
4500

Mechatronic
RC 2000

Zehntner 6060

Road Vista 922
AASHTO M268 TYPES vs ASTM TYPES - White Sign Sheeting

Coefficient of Retroreflection ($R_A$)

Entrance Angle / Observation Angle

0.5 / -4

Entrance Angle / Observation Angle

Types

A
B
C
D
II
III
VIII
IX
XI
Retroreflectivity Concepts

MEASURING PAVEMENT MARKING RETROREFLECTIVITY
Retroreflectivity Concepts

• ASTM D7585-10 Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments

• ASTM WK3833 Test Method for Mobile Pavement Marking Retroreflectivity Measurements


• ASTM E2832 - 11 Standard Test Method for Measuring the Coefficient of Retroreflected Luminance ($R_L$) of Pavement Markings in a Standard Condition of Wetness

• ASTM E2832-12 Continuous Wet Method Standard Test Method for Measuring the Coefficient of Retroreflected Luminance of Pavement Markings in a Standard Condition of Continuous Wetting (RL-2)
Retroreflectivity Concepts

Drawing not to scale

Observation angle $\alpha$

Entrance angle $\beta$

Distance
Retroreflectivity Concepts

Light rays entering the glass beads are retroreflected back to the driver.

Glass Bead

Paint Binder

Painted Surface

Glass Bead Retroreflection
Retroreflectivity Concepts

Types of Pavement Marking Materials

1. Paint
2. Thermoplastic
3. Preformed Thermoplastic
4. High Performance Tapes
5. Audible & Vibratory Markings – Rumble Strip
6. Wet Weather Markings
7. Two Component Reactive
Retroreflectivity Concepts

ASTM WK3833 Test method for mobile pavement marking retroreflectivity measurements
Retroreflectivity Concepts

ASTM D7585-10 Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments
CALIBRATION OF TESTING EQUIPMENT
Measuring dry retro of the rumble stripe.
Note: Stabilizing plate is optional.
New Tape
Retro = 1000 mcd

1 Year old Tape
Retro = 500 mcd
Retroreflectivity Concepts

ASTM E2177 - 11  Standard Test Method for Measuring the Coefficient of Retroreflected Luminance ($R_L$) of Pavement Markings in a Standard Condition of Wetness – Bucket Method or Spray Method
Retroreflectivity Concepts

Retroreflectivity Concepts

Questions?
• **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.
MUTCD Maintenance Methods

- Visual Nighttime Inspection (VNI)
  - Calibration Signs
  - Comparison Panels
  - Consistent Parameters
- Measured Sign Retro
  - Handheld
  - Mobile
- Expected Sign Life
- Blanket Replacement
- Control Signs
- Future Method Based On Engr. Study
- Combination Of Any
Implementation and continued use of an assessment or management method that is designed to maintain regulatory and warning sign retroreflectivity at or above the established minimum levels

June 13, 2014
# Agency Sign Retro Practices

## Table 1: Distribution of Method Selection

<table>
<thead>
<tr>
<th>MUTCD Assessment and Management Methods</th>
<th>Primary Sign Replacement Method</th>
<th>Secondary or Support Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local Agencies*</td>
<td>State DOTs</td>
</tr>
<tr>
<td>Nighttime Inspection</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Measured Retroreflectivity</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Expected Sign Life</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Blanket Replacement</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Control Signs</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Local agencies include towns, cities, counties, and one toll road agency. The sum of the Primary Sign Replacement Method columns numbers 40. The Secondary or Support Method columns add to a lesser number because there is no requirement that there be a secondary method and agencies may have multiple support methods.

**NCHRP 431 - Survey conducted in 2011**
# State DOT Sign Retro Practices

<table>
<thead>
<tr>
<th>Maintenance Method</th>
<th>State DOTs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>VNI – Calibrated Signs</td>
<td>13</td>
<td>Inspection intervals: 1, 2, 3 years</td>
</tr>
<tr>
<td>VNI – Comparison Panels</td>
<td>3</td>
<td>Option</td>
</tr>
<tr>
<td>VNI – Consistent Parameters</td>
<td>2</td>
<td>Option</td>
</tr>
<tr>
<td>Measured Retro</td>
<td>1</td>
<td>Option</td>
</tr>
<tr>
<td>Expected Service Life / Blanket Replacement</td>
<td>20</td>
<td>10, 12, 15, 17 yrs</td>
</tr>
<tr>
<td>Control Signs</td>
<td>2</td>
<td>Support</td>
</tr>
</tbody>
</table>

AASHTO - Survey conducted in 2014
Markings for Machines

Lane Departure Warning
Lane Keeping Assistance
Highway Safety Statistics

- Roadway departure crashes account for over half of all fatal crashes in the US (51%)
Potential LDW Safety

- Decrease fatalities by 7,529 fatal per year in the US
  - *Journal of Accident Analysis & Prevention, Vol 43, 2011*
- Reduce roadway departure crashes 26.1%
  - *NHTSA*
- Reduce serious injuries 20.7%
  - *NHTSA*
Day and Night Field Testing

Images courtesy of TTI
On-Going Research

• NCHRP 20-102: *Impacts of Connected Vehicles and Automated Vehicles on State and Local Transportation Agencies*

• Task 6: *Road Markings for Machine Vision*

• Objectives
  – develop information on the performance characteristics of pavement markings that affect the ability of machine vision systems to recognize them
  – provide data and recommendations that the AASHTO/SAE Working Group can use to quickly develop guidelines and criteria
Field Data
Texas A&M RELLIS Campus
Markings (Level 1)
Markings (Level 2)
Markings (Level 3)
Markings (Level 4)
Markings (Level 5)
Test Markings

- Test Markings (all 4-inch wide)
  - Continuous white
  - Continuous yellow
  - Skip white
  - Skip yellow
    - Raised retroreflective pavement markers
    - Raised non-retroreflective pavement markers
Test Conditions

• Daytime
  – Weather (dry, wet)

• Nighttime
  – Conditions (dry, wet)
  – Continuous roadway lighting (on or off)
Expected Results

• Pavement marking criteria for machine vision
  – Daytime contrast ratios
    • Contrast markings
  – Nighttime retroreflectivity levels

• SAE/AASHTO will develop a collaborative standard to provide guidance for highway agencies and design criteria for automotive industry
Sensor-Enhanced Markings

- Pilot testing of enhanced detection technologies