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.

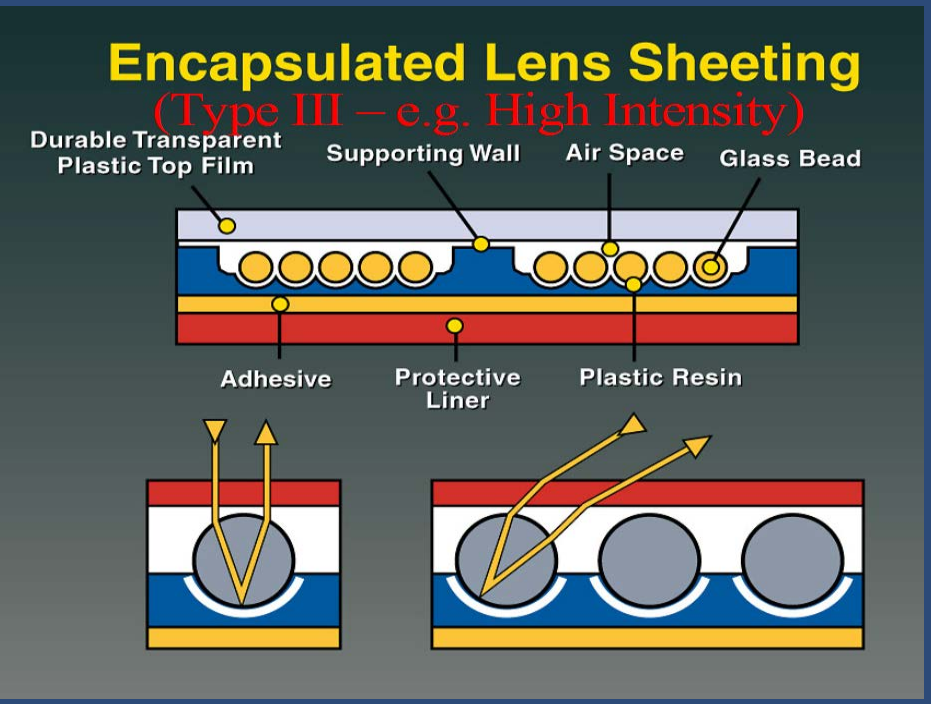
Sign sheeting material may degrade over time in different areas of the sign.

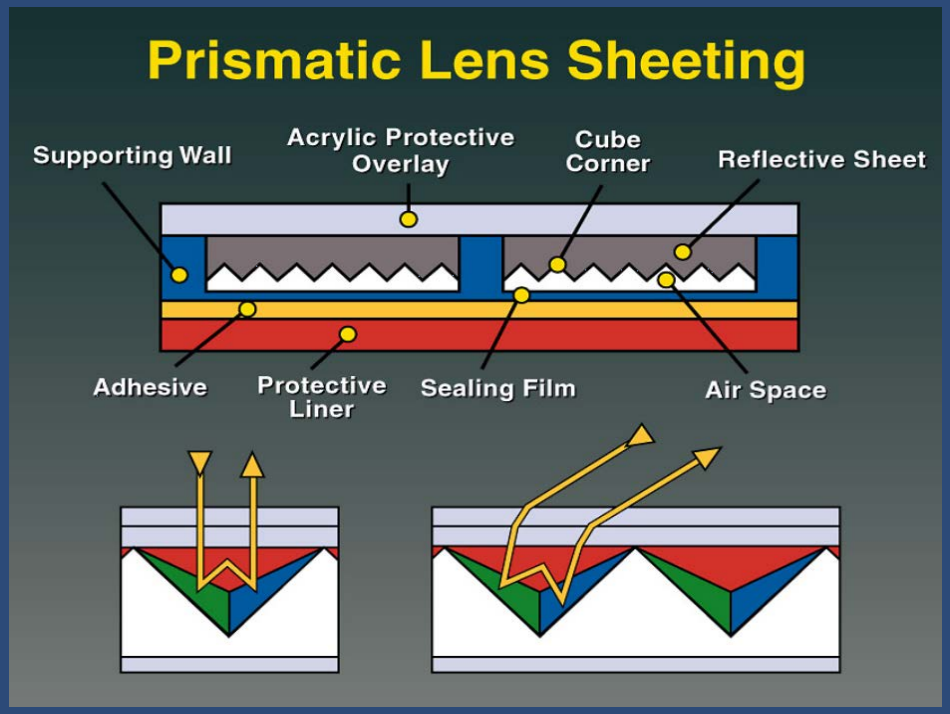
Sign Retroreflectivity Specifications

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. ($cd/lx/m^2$)

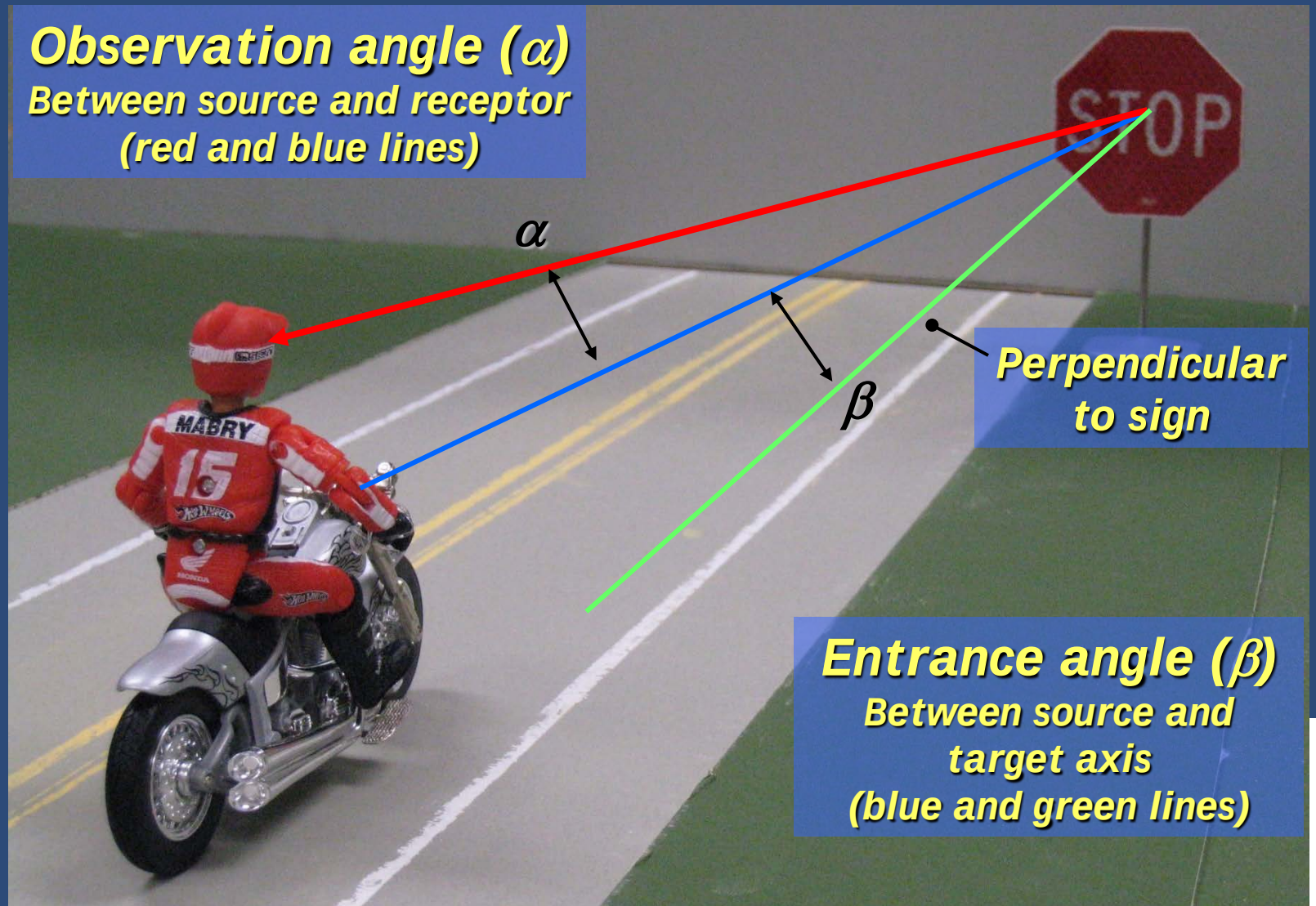
Sign Sheeting Types





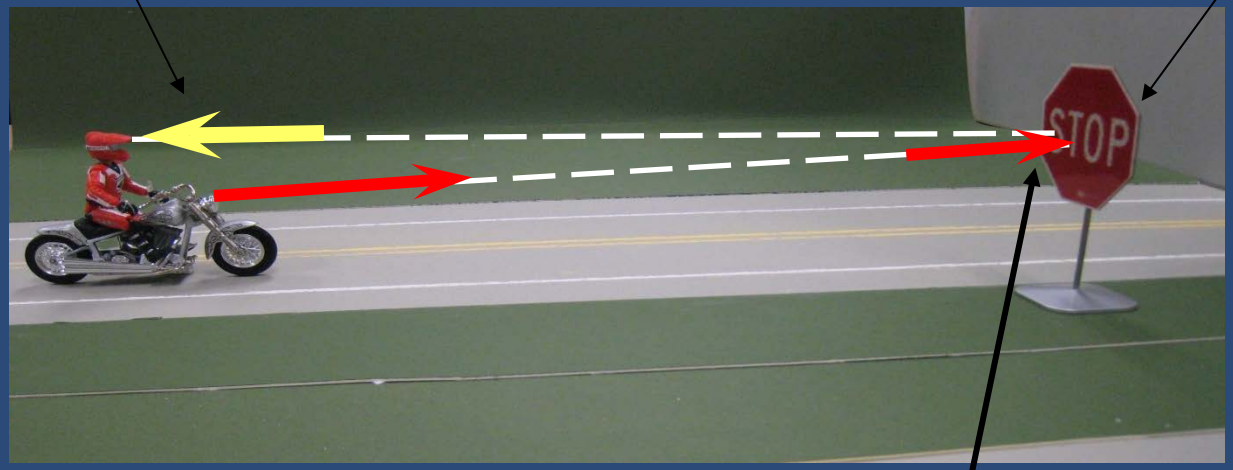
Key Geometry Angles (0.2/-4)

Observation angle = 0.2° Entrance Angle = -4°



Technical Terms = Retroreflectivity R_A = $cd/lx/m^2$

Luminance
(cd/m^2)



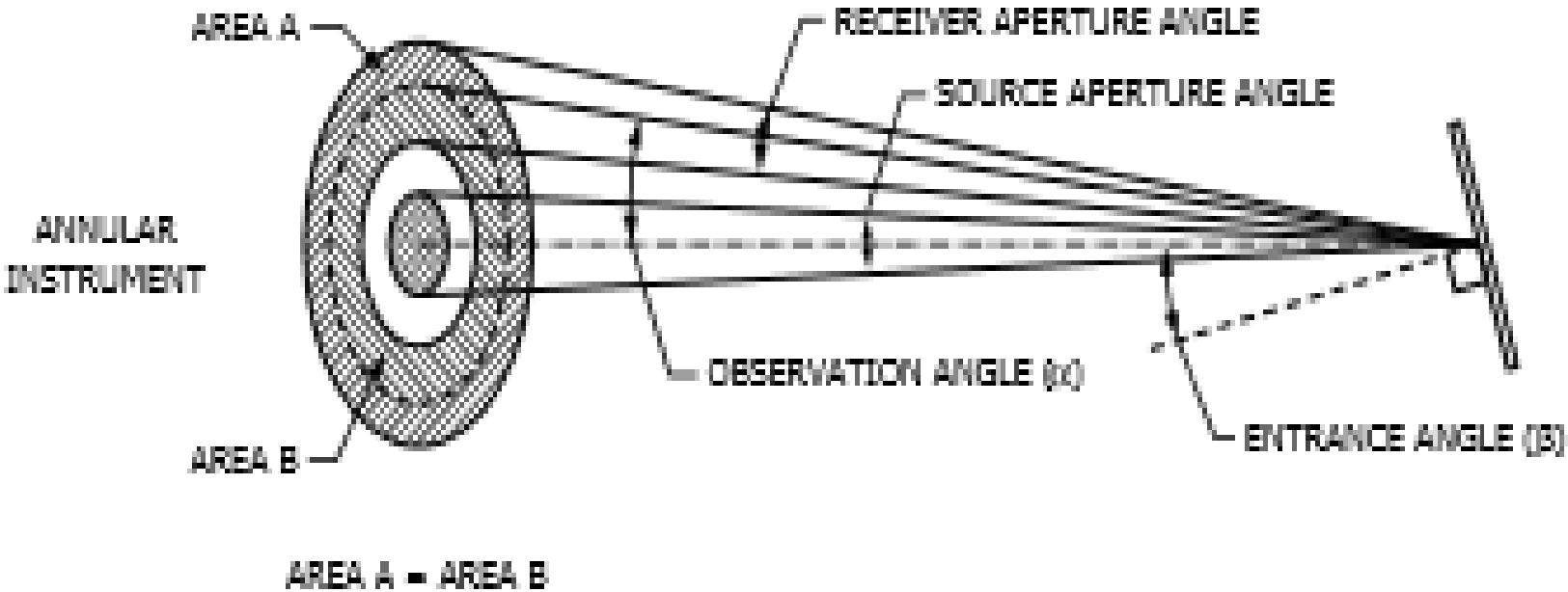
Illuminance (lx)

Portable Retroreflectometers – Different Types

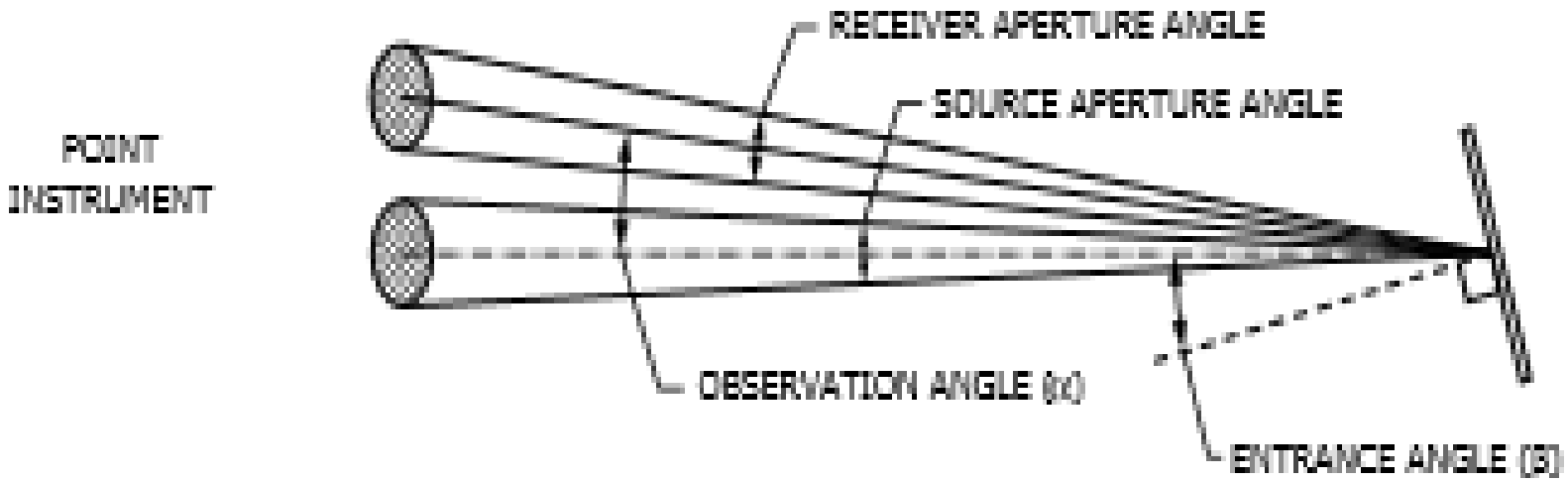
Point Instrument - has a single light detector next to the light source or axis and makes an R_A measurement virtually identical to an R_A measurement made on a lab range system where the light detector is on top of the light source. Like the motorcycle illustration. Typical R_A specifications require 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.


AREA A
RECEIVER APERTURE ANGLE
SOURCE APERTURE ANGLE
ANNULAR INSTRUMENT
OBSERVATION ANGLE (α)
ENTRANCE ANGLE (β)
AREA B

AREA A = AREA B


RECEIVER APERTURE ANGLE
SOURCE APERTURE ANGLE
POINT INSTRUMENT
OBSERVATION ANGLE (α)
ENTRANCE ANGLE (β)

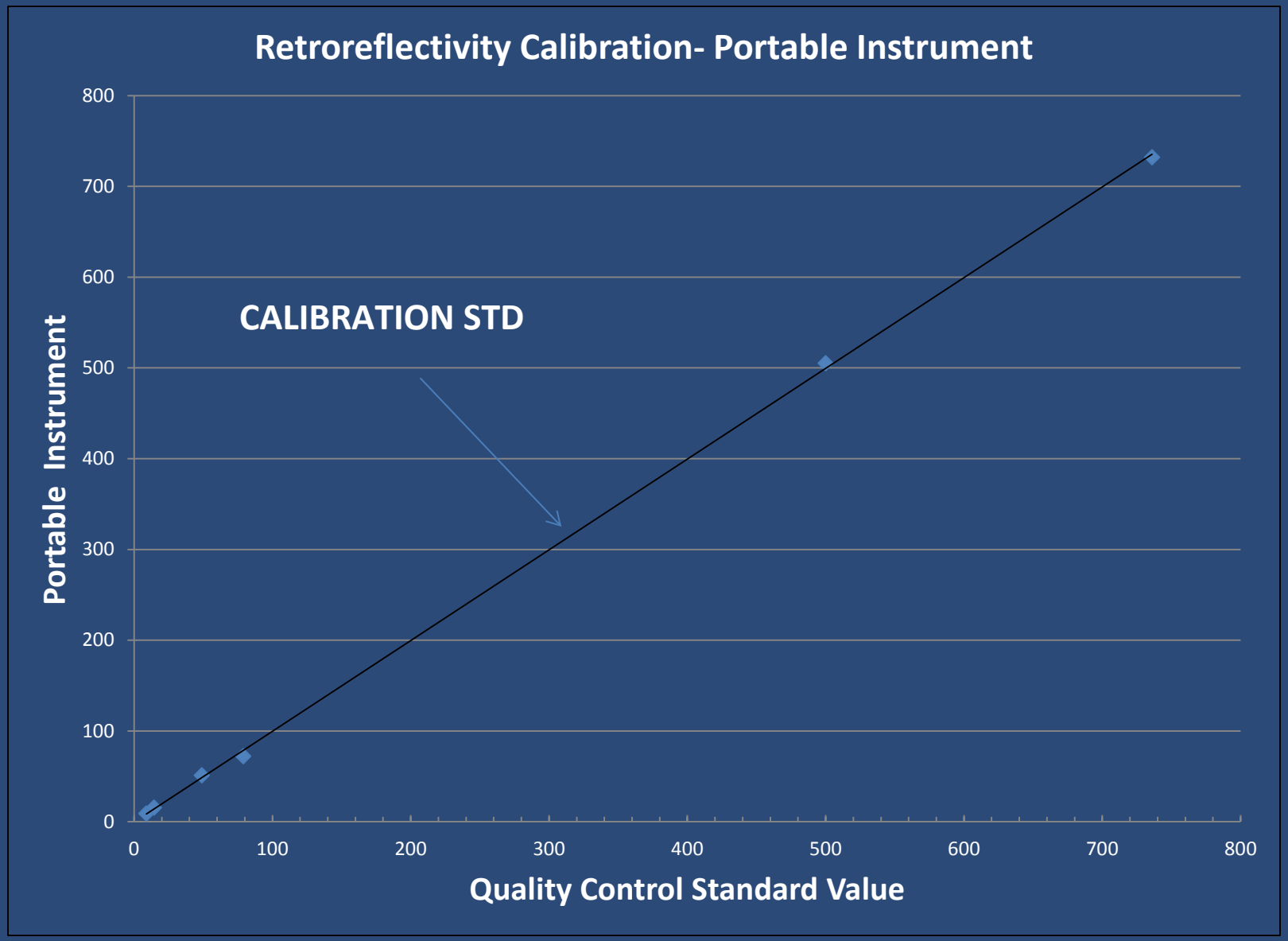
Point Instrument – Zero Degree Measurement

Point Instrument – 90 Degree Measurement

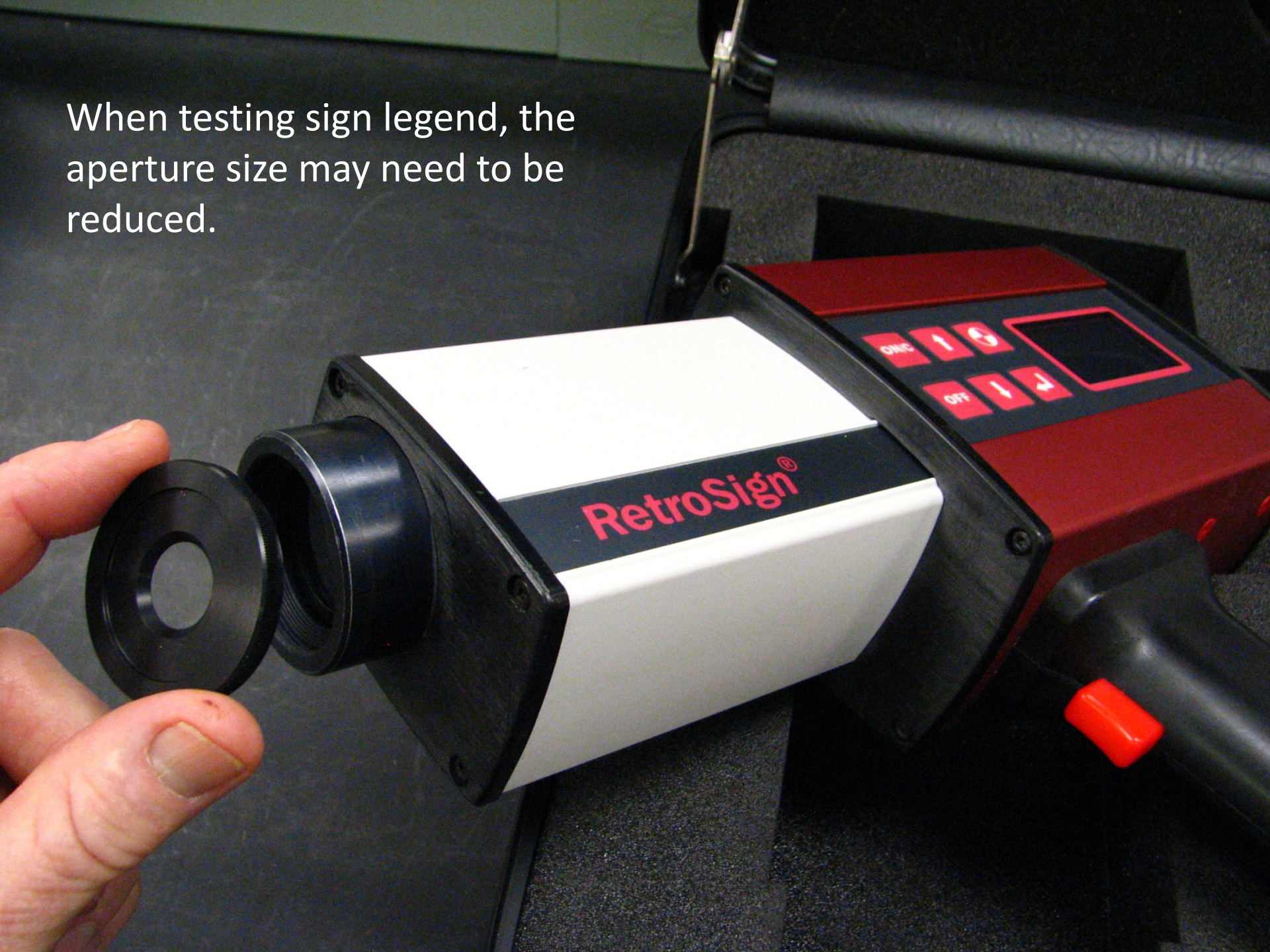
Calibrating the Instrument

Example of testing a Quality Control sample (low retro value).

Example of testing a Quality Control sample (high retro value).


Retroreflectivity Calibration- Portable Instrument
CALIBRATION STD
Portable Instrument
Quality Control Standard Value
0
100
200
300
400
500
600
700
800

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

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 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

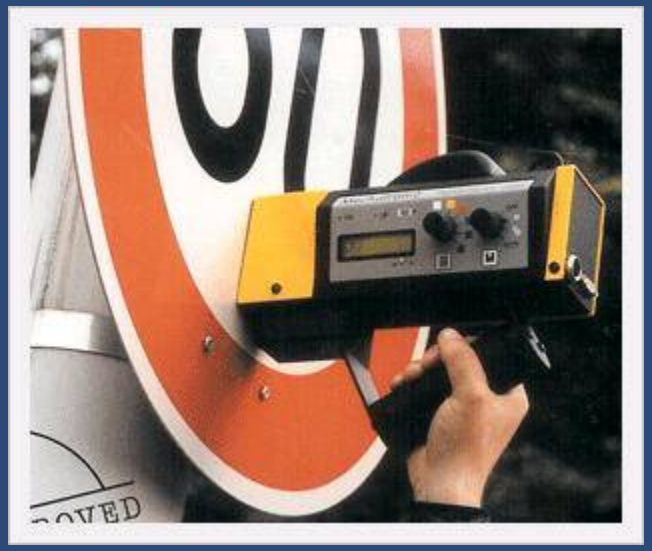
[A] Minimum Coefficient of Retroreflection (R_A) cd/fc/ft^2(cd·lx^{-1}·m^{-2}).

[B] Values for 0.1° observation angle are supplementary requirements that shall apply only when specified by the purchaser in the contract or order.

Portable Retroreflectometers

Delta
Retrosign
4500

Mechatronic
RC 2000



Zehntner 6060

Road Vista 922

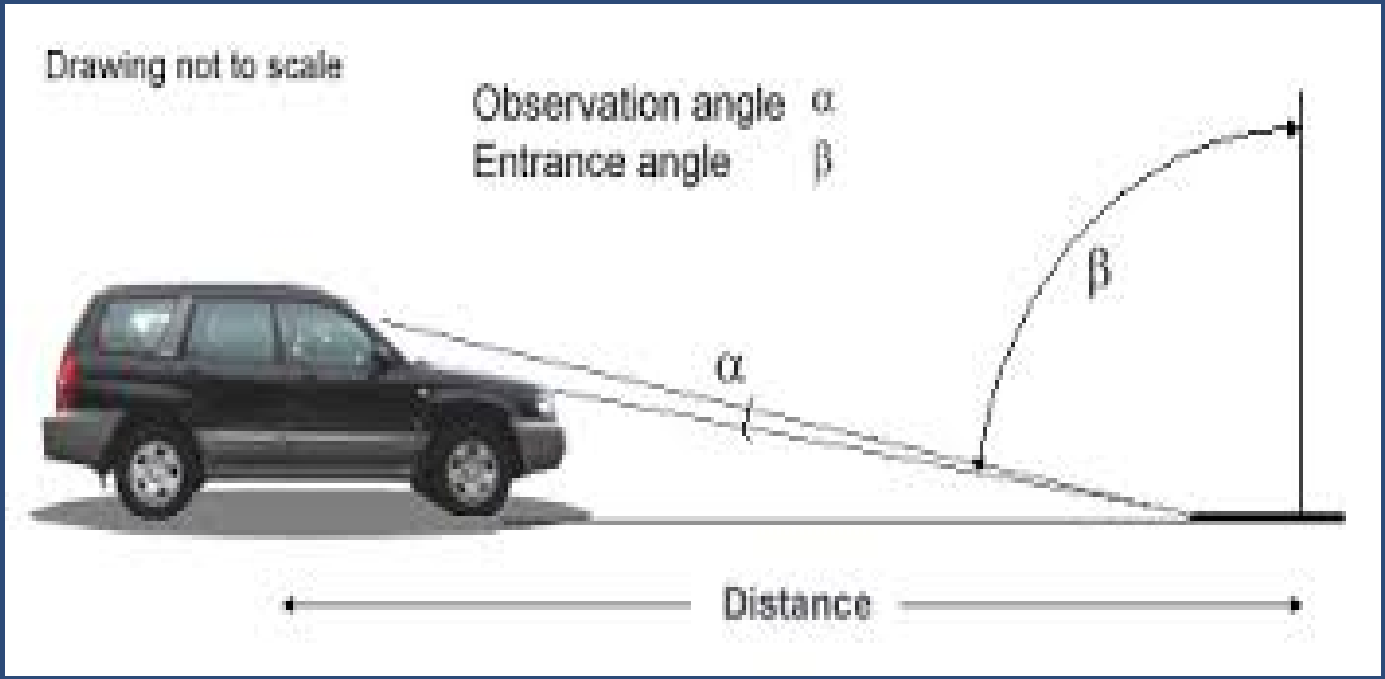
Retroreflectivity Concepts

MEASURING PAVEMENT MARKING RETROREFLECTIVITY

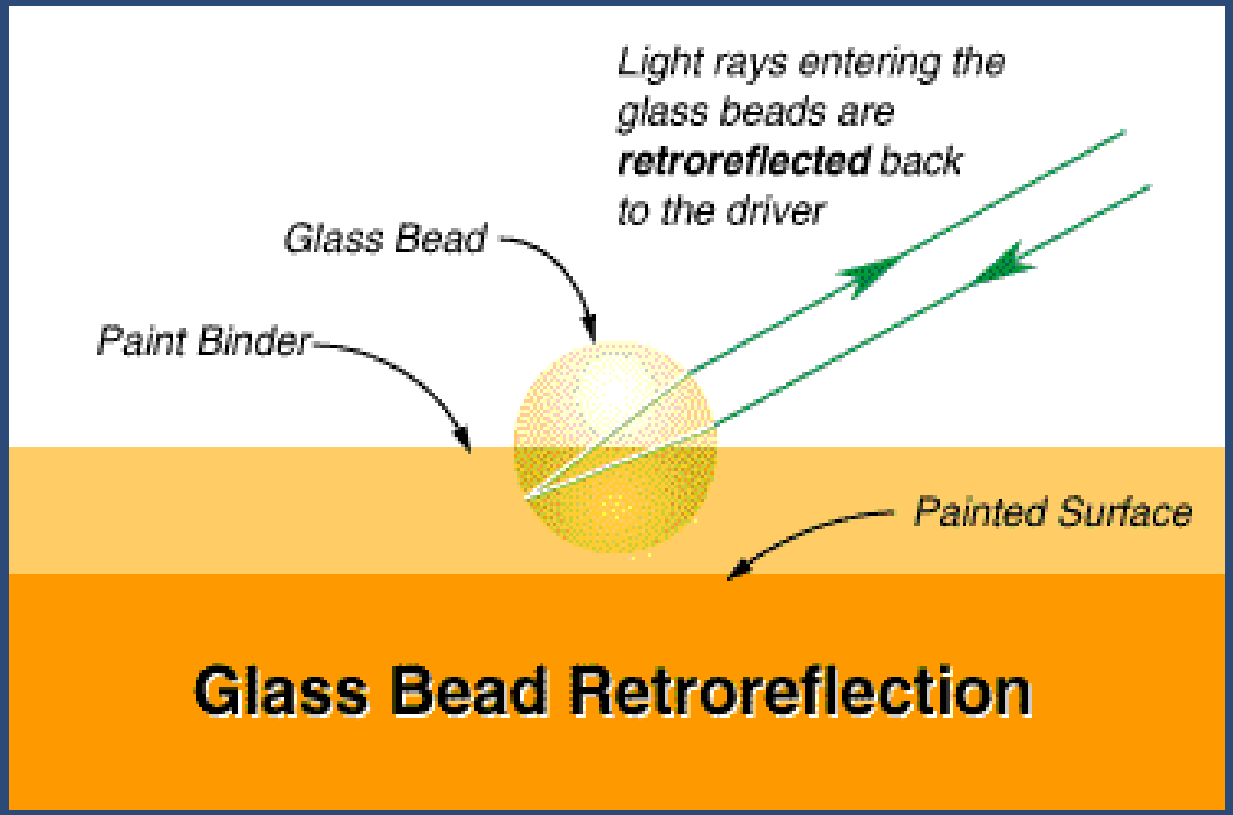
Retroreflectivity Concepts

- 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 E1710-11 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry using a Portable Retroreflectometer
- 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



Retroreflectivity Concepts



Retroreflectivity Concepts

Types of Pavement Marking Materials

1. Paint
2. Thermoplastic
3. Preformed Thermoplastic
4. High Performance Tapes
5. Audible & Vibratory Markings
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

Retroreflectivity Concepts

ASTM E1710 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry using a Portable Retroreflectometer.

CALIBRATION OF TESTING EQUIPMENT

FOR THE PROTECTION OF
THE DISPLAY AND LONGEVITY
OF THE INSTRUMENT, KEEP
THE SHIELD CLOSED WHEN
THE LTL-X IS NOT IN USE
2319


MEASURE
2810
MAR 11 2014 02:06:34 PM
ID: S1
2622
PR
RXR
STOP
ONLY
SCHOOL

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


Columbia


GDOT
ett Place

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 – Spray Method

Retroreflectivity Concepts

ASTM E2832 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)


solo
THIS SIDE UP
FRAGILE


G90

THE CORD TO THE CONTROL BOX, OTHERWISE FALSE READINGS MAY OCCUR.

SET-UP

The cylinder platform may be used either in the [illegible] or removed from the case to provide extra clearance and convenience.

1. Before using, determine whether the platform will be used in or out of the case and place the unit on a firm and level surface.
2. Switch the unit on by pushing the **ON/OFF** button.
3. Select the desired unit of measure by pressing and releasing the **UNITS** button.
   3 scales are available
   Lbs./oz. (0.0 Lbs. 0.0 oz.)
   Decimal Pounds (0.000 Lbs.)
   Kilograms (0.000 kg)

OPERATION

1. Carefully place refrigerant cylinder in the center of the platform.
2. Connect the refrigerant cylinder to a charging manifold via utility hose if charging refrigerant or to a recovery machine if recovering refrigerant.
3. Open refrigerant tank valve and purge air from hoses.
4. Press the **ZERO** button, the display will change to zero.
5. Open manifold valve(s) or turn on recovery unit, refrigerant will begin to flow and the display will indicate the weight being removed (if charging) or added (if recovering). A minus sign (-) will appear if the weight is being removed.
6. Monitor the display; when desired charge or maximum allowable fill is reached, close the cylinder valve, manifold valves and/or switch off the recovery unit.
7. When operation has been completed, turn the unit off by pushing the **ON/OFF** button. Close cylinder valve, disconnect hose(s) and store.

LOW RESOLUTION MODE

In Normal operating mode, the extremely high resolution of the scale may lead to small, yet noticeable, fluctuations in the reading caused by weight shifts or wind. To alleviate this a Low Resolution mode may be activated.

1. With the scale switched on, with any unit or weight display, press and hold the **UNITS** button.
2. The enunciators will begin to flash.

[illegible] operation. Resolution is now reduced by a factor of 5 (0.5 oz./0.025 Lbs./10g) and will provide stable reading under extreme conditions. To return to the normal resolution mode, depress the **UNITS** button again, and hold until the enunciators stop flashing.

WEIGHT MEASUREMENTS

1. The unit may be used strictly as a weigh scale.
2. Follow steps 1 through 4 in Set-Up.
3. Press the **ZERO** button, the display will change to zero.
4. Carefully place the object (e.g. cylinder) that is to be weighed directly in the center of the platform.
5. Gross weight will be displayed.
6. When weighing has been completed, turn the unit off.

This feature is especially useful when recovering. To calculate the amount of refrigerant in a tank subtract the "Tare" weight (marked on cylinder) from the displayed amount to find the quantity of refrigerant in the cylinder.

OVERRANGE INDICATION

If the Gross Weight applied to the platform exceeds the specified range, the unit will display a single 1 at the left of the display.

BATTERY INSTALLATION

The BATTERY enunciator will appear when the battery needs replacing. "---" on display indicates battery voltage insufficient for operation. Replace battery in order to resume operation.

1. Remove the battery from the control box by removing the battery cover located on the back of the box.
2. Disconnect the battery from the battery clip.
3. Attach a new 9v alkaline battery.
4. Replace new battery and cover.

EXPANSION PORT

The 9010A has a jack on the right side of the control box. This permits connection to the optional 9020 Remote Charging Module. Please refer to instructions with the 9020 for use.

SPECIFICATIONS

Range:	0Lbs.0.0oz. to 110 Lbs. 0.0oz. or 0.000Lbs. to 110.000Lbs. or 0.000kg to 55.000kg
Resolution:	
Normal:	0.1 oz./0.005 Lbs./2g OR
Low:	0.5 oz./0.025 Lbs./10g
Accuracy:	+/- 0.5% of reading +/- 1 digit
Power Supply:	One 9V alkaline battery
Battery Life:	30 hrs (approx.)
Operating Temperature:	32°F to 120°F (0°C to 49°C)
Weight:	6.15 lbs (2.79 kg)
Dimensions:	15.25 x 10.5 x [illegible] (38.7 x 26.7 x [illegible])

Warranty and Repair Policy

This instrument has been produced to provide unlimited service. Should it become inoperative after the user has performed the recommended maintenance a no charge repair or replacement will be made to the original purchaser. This applies to all repairable units that have not been damaged or tampered with. The claim must be made within **Two** years of the date of purchase. For repair call Customer Service:

Advanced Test Products, Inc.
1-800-327-5060

An additional 90 day warranty period will [illegible] service unit. If you have [illegible] assistance please [illegible] number to speak with a [illegible] representative.

Béton Ltd.
Physical Testing Equipment
P.O. Box 80151 Phone (404) 387-1907
Atlanta, GA 30366 Fax (404) 812-9826

Manufactured in China. PL643 Rev.G

DISPLAY INDICATIONS

CE SPX TIF

WARNING: Do not use in high electrical noise environments as a variant of readings could occur.


MARSH
psi
kPa
0
5
10
15
20
25
30
30
60
90
120
150
180
210


THIS SIDE UP
FRAGILE
THIS SIDE UP
FRAGILE
ROADVISTA
StripeMaster 2 Touch

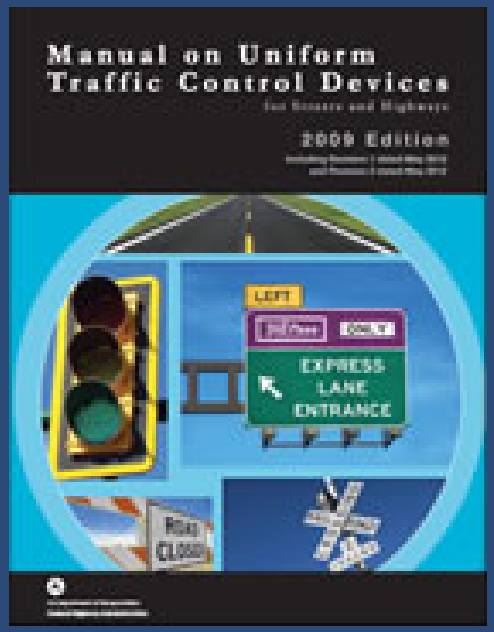
Retroreflectivity Concepts

Questions?

New MUTCD Language - Section 2A.08 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"



MUTCD Sign Retro Methods

Assessment Methods

- Visual Nighttime Inspection
  - Calibration Signs
  - Comparison Panels
  - Consistent Parameters
- Measured Sign Retro

Management Methods

- Expected Sign Life
- Blanket Replacement
- Control Signs

Visual Inspection Requirements

- ***Trained inspector***
- Nighttime inspection
- Need to tie to minimum values by using one of the following techniques:
  - Comparison panels procedure, or
  - Calibration signs procedure, or
  - Consistent parameters procedure

Visual Inspection Method: Comparison Panel Procedure

- Any vehicle, any inspector age is OK.
- The “initial” inspection occurs at highway speeds.
- When a marginal sign is spotted,
  - Safely pull over to inspect the sign,
  - Install comparison panel on the sign,
  - Evaluate from at least 25 feet,
  - Hold a flashlight near inspector’s ear.

Visual Inspection Method: Calibration Sign Procedure

- Any vehicle, any inspector age is OK.
- Before leaving the maintenance yard, the inspectors visually inspects a set of representative signs in an effort to calibrate their eye before starting the nighttime inspections.
- The calibration signs should be viewed at distances from 600 to 100 feet

Visual Inspection Method: Consistent Parameter Procedure

- Model year 2000 or later SUV or truck.
- Inspector needs to be at least 60 years old.
- The inspection occurs at highway speeds.
- No calibration signs or comparison panels are needed.

Retroreflectivity Measurement Method

HANDHELD
Model GR3
by Delta
www.tapconet.com/digital

HANDHELD
Model 922
by Road Vista
www.roadvista.com

MOBILE
AMAC
by DBi Services
www.amacglobal.com

MUTCD Sign Retro Methods

Assessment Methods

- Visual Nighttime Inspection
  - Calibration Signs
  - Comparison Panels
  - Consistent Parameters
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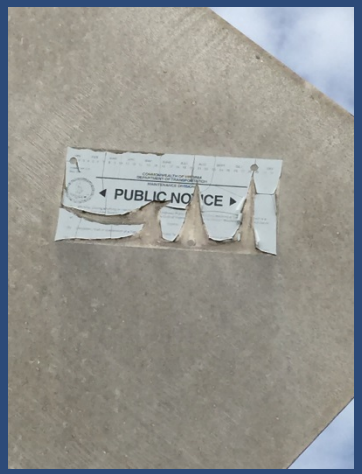
- Expected Sign Life
- Blanket Replacement
- Control Signs

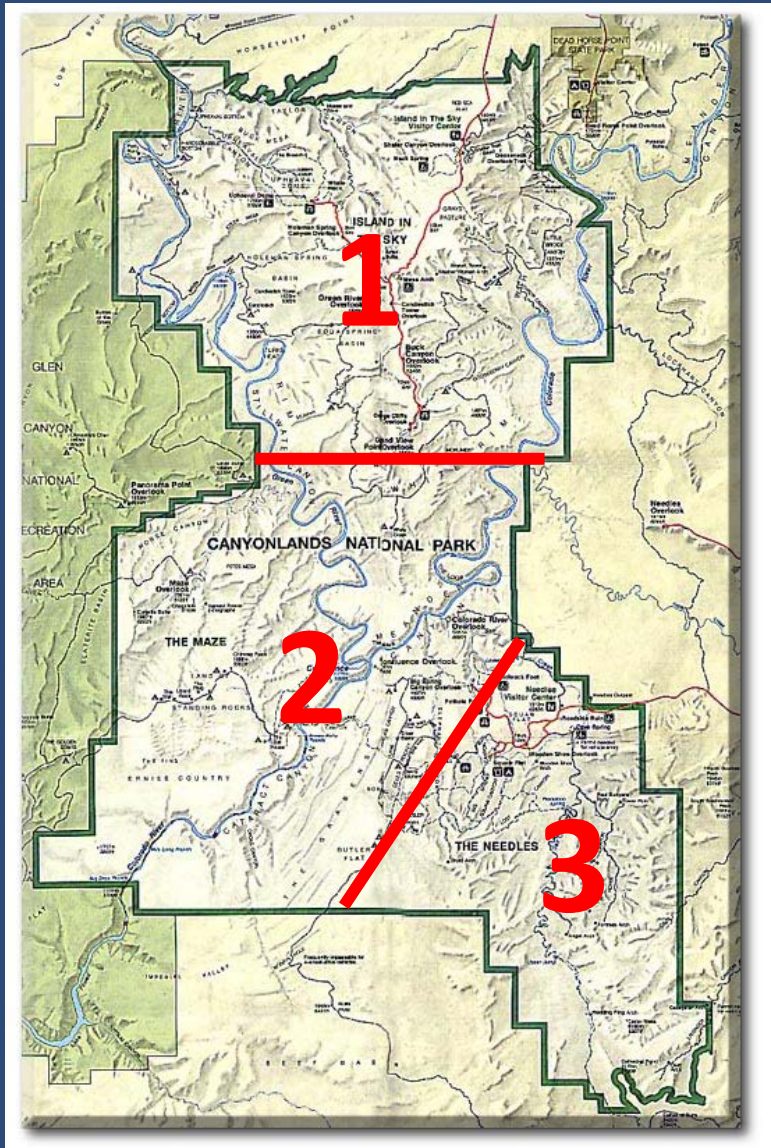
Expected Sign Life Method

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



Blanket Replacement Method

- Divide agency into areas
- Relate number of areas to replacement cycle
- Replace all signs in an area each replacement cycle
- If 12 year life is used, then
  - Area 1 = 2015
  - Area 2 = 2019
  - Area 3 = 2023
  - Area 1 = 2027 …



Control Signs Method

- Sign life estimated using subset of signs representing 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 (measures) control signs to estimate condition of all signs.

Example of Control Signs

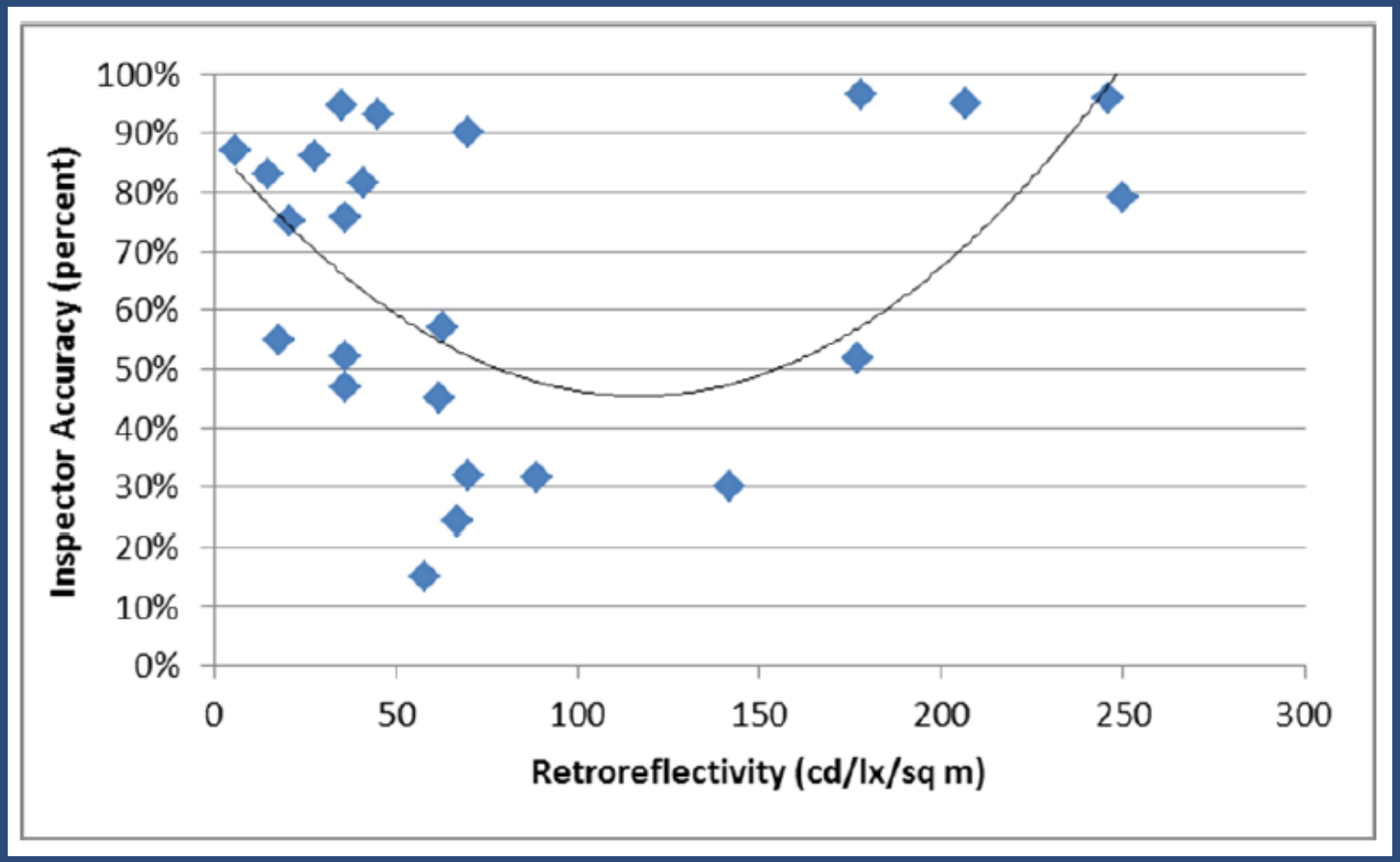
Effectiveness

- Nighttime Visual Inspection
- Measured Retroreflectivity
- Service Life / Blanket Replacement

Nighttime Visual Inspection Studies

- Washington DOT
  - Traffic Sign Retroreflectivity Measurements Using Human Observers. WA-RD 140.1, Washington DOT, Olympia, Washington, December 1987.
- Texas DOT
  - Sign Retroreflectivity-Comparing Results of Nighttime Visual Inspections with Application of Minimum Retroreflectivity Levels. In Transportation Research Record 1754, Transportation Research Board. Washington, DC. 2001.
- FHWA
  - Workshops on Nighttime Visibility of Traffic Signs: Summary of Workshop Findings. FHWA-SA-03-002, US DOT, FHWA, Washington, DC., February 2003.

Visual Inspection Accuracy

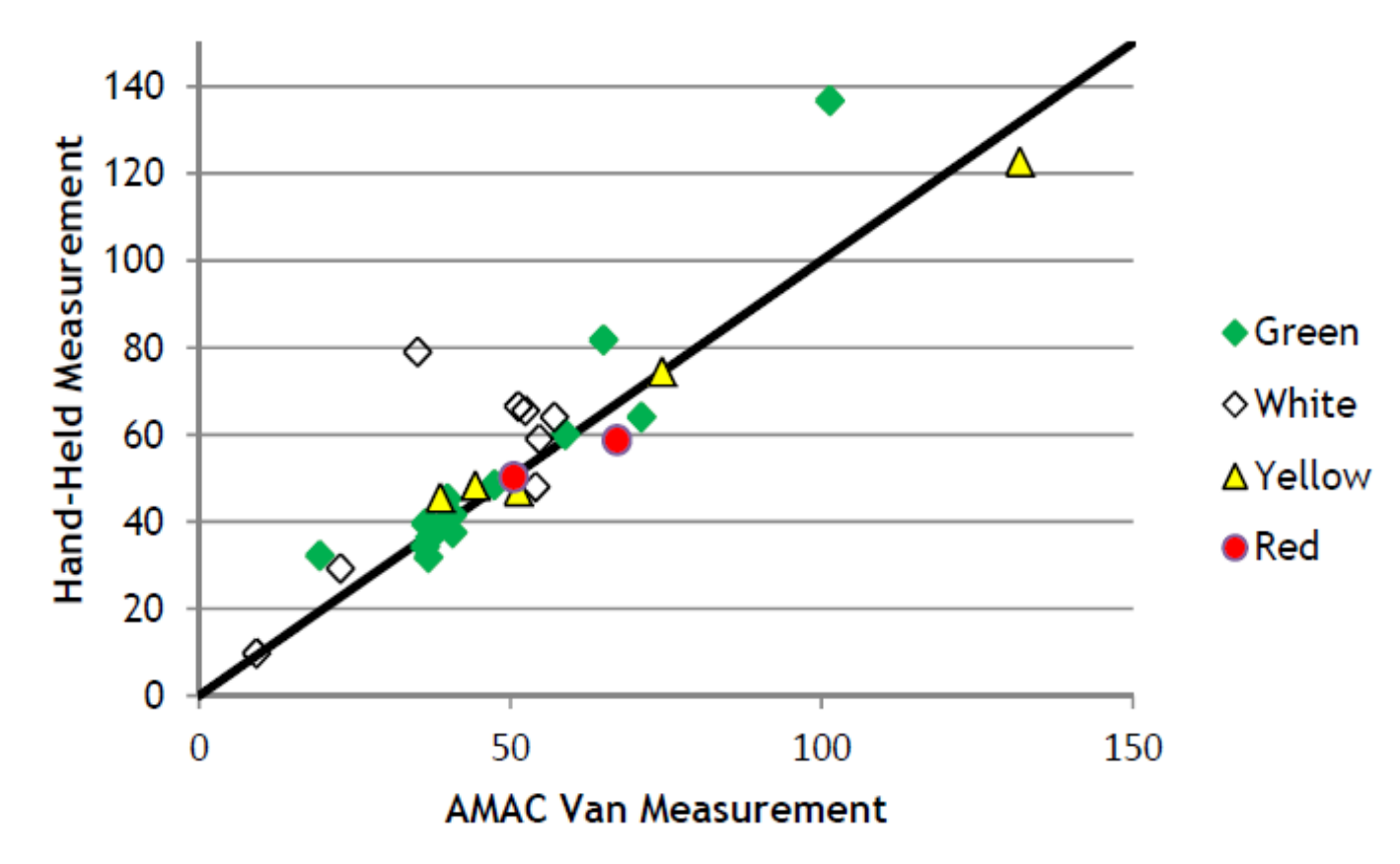


Recent Field Evaluations

Visual Nighttime Inspection with Trained Inspectors

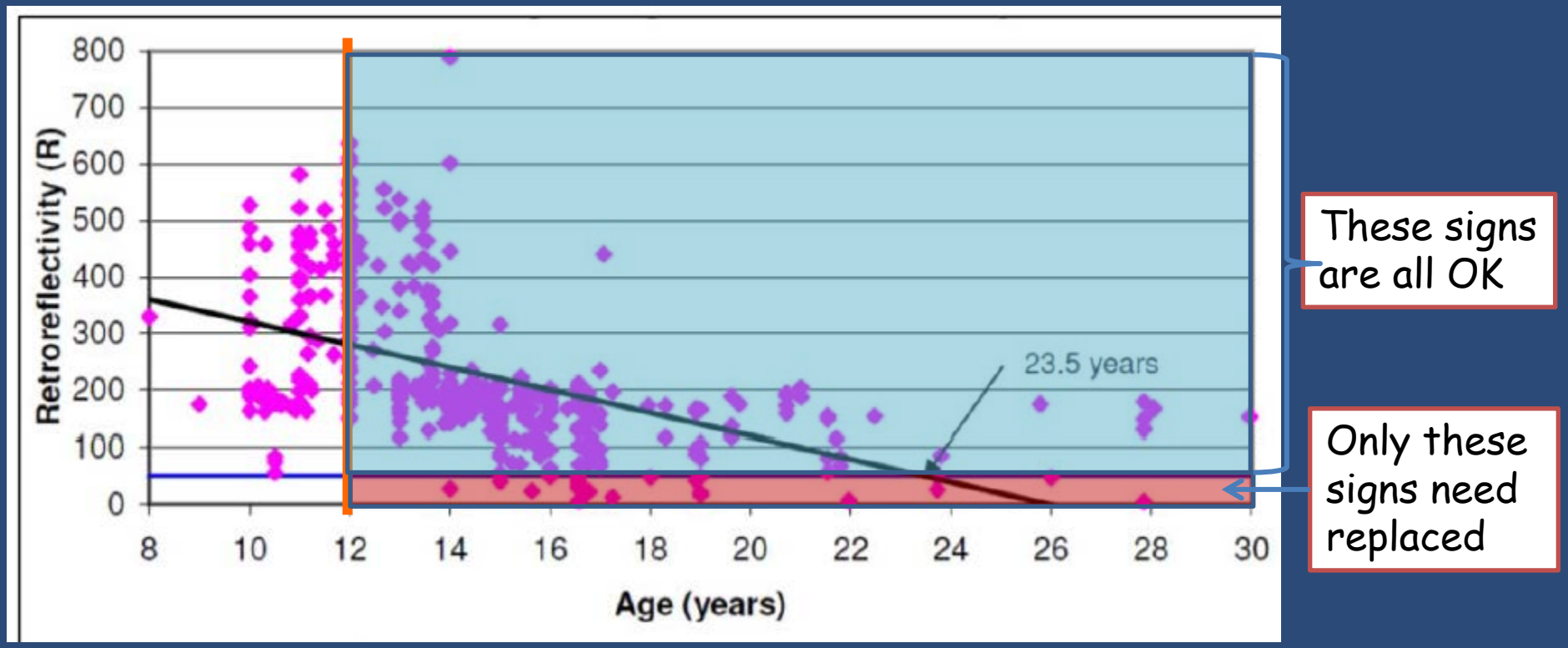
Measured Retroreflectivity	Number of Signs	Agreement with Measured Retro
0-50	5	5 (100%)
51-100	6	1 (16.7%)
101-150	4	4 (100%)
>150	17	17 (100%)

Mobile Retro Accuracy



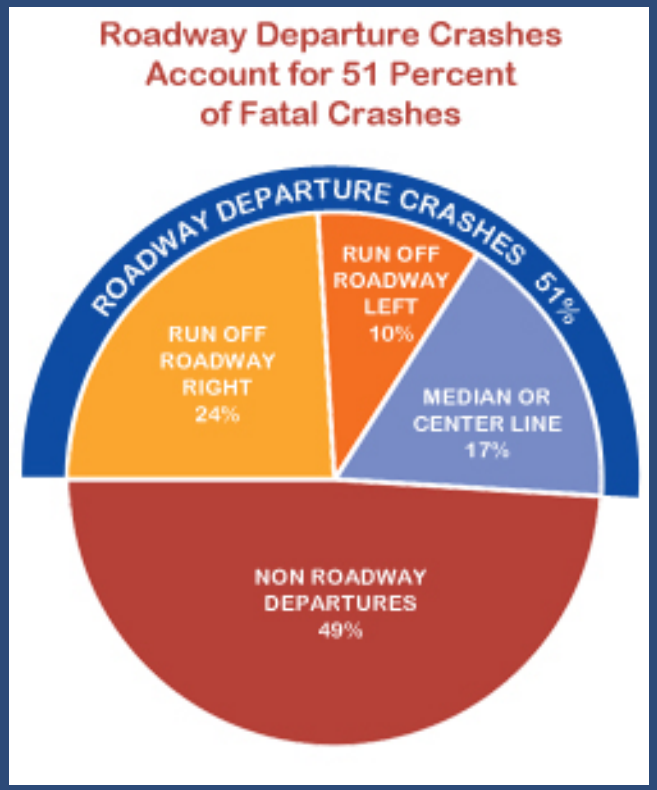
Evaluation of Service Life

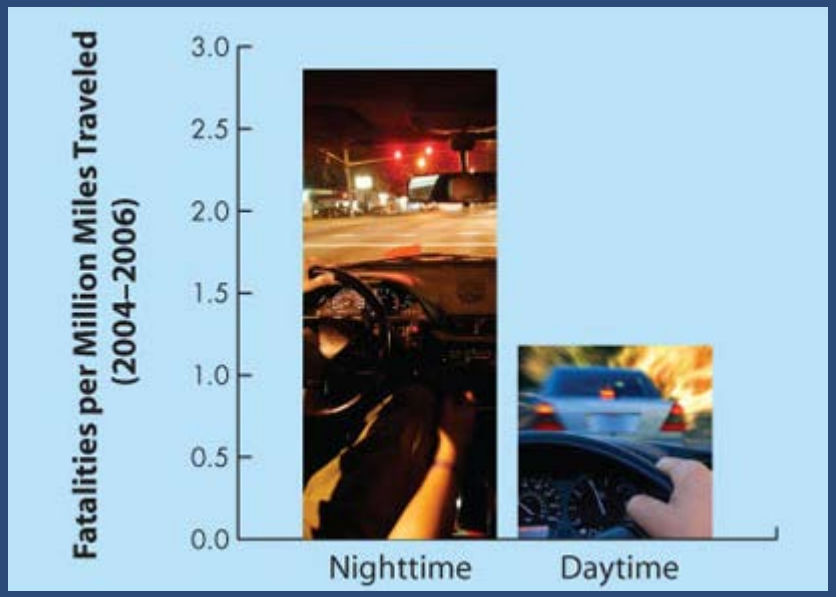
Warning sign retro data from a state in the North East



Vehicle Cameras Detect Markings

Highway Safety Statistics





Potential LDW Safety

LDWs have the potential to prevent or mitigate 7,529 fatal and 37,000 injury accidents per year in the US

(*Journal of Accident Analysis & Prevention, Vol 43, 2011*)

IIHS Findings on LDW (2014)

- Not effective as other vehicle safety technologies
- “we don’t see any evidence that these systems are helping drivers avoid being in crashes”
- Drivers are reported the LDW can be annoying
- “turn signal nanny” effect

TTI Lab studies (2014)

- Objectives
  - Investigated marking properties that would make detection with machine vision more reliable
  - Explored various camera technologies
  - Studied lighting options
    - Visible
    - Infrared

Field Studies (2015)

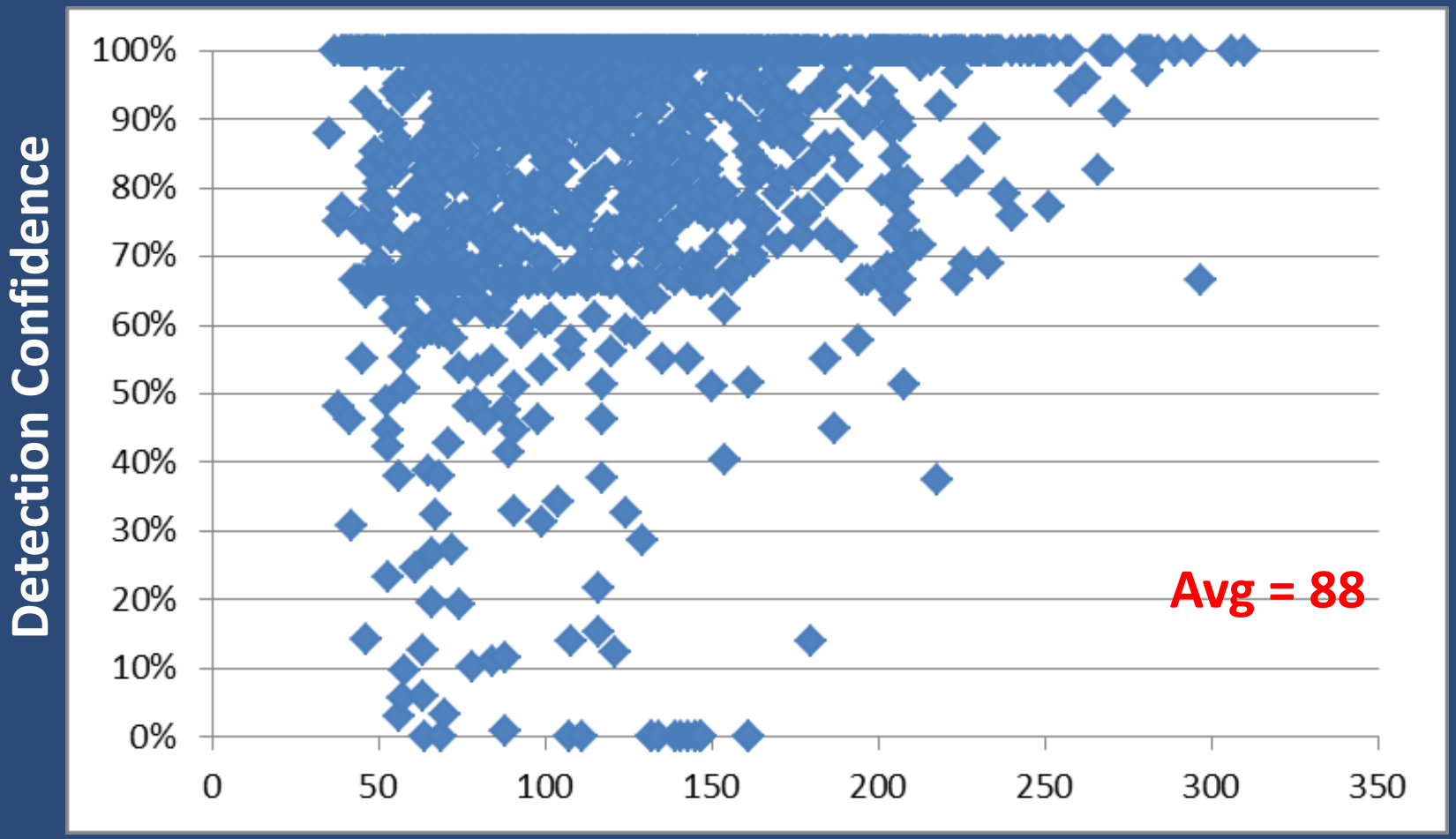
- Linking machine vision detection to:
  - Contrast (daytime)
  - Retroreflectivity (nighttime)
- What can agencies do to enhance their road to be ready for camera-based vision?

Video demo

Daytime

Nighttime

Preliminary Data



Measured Retroreflectivity (mcd)
White Edge Line

Same Curve

Many Challenging Conditions

- Uniform road marking maintenance thresholds
  - Daytime Contrast & Nighttime Retroreflectivity
- Preventive pavement maintenance treatments
- Horizontal curves
- Roadway lighting
- Tunnels, bridges, shadows
- Wet / snow conditions
- Debris
- Poor marking removal


B D
A C

NCHRP 20-102(6) - Road Markings for Machine Vision

- The objective of the research is to obtain data that can be used to develop correlations between machine vision performance and pavement markings. Factors to be considered are pavement marking presence, contrast, retroreflectivity, pavement uniformity, day and night conditions, and vehicle speed. It is intended that the work include a range of forward-facing cameras and their respective software so that the current technologies and those on the horizon can be accommodated by the new guidelines/criteria.