TRB Webinar

Signs and Pavement Marking Retroreflectivity – Measurement Basics, Safety Benefits, Advancements: A State Department of Transportation (DOT) Perspective

Sign retroreflectivity levels will vary

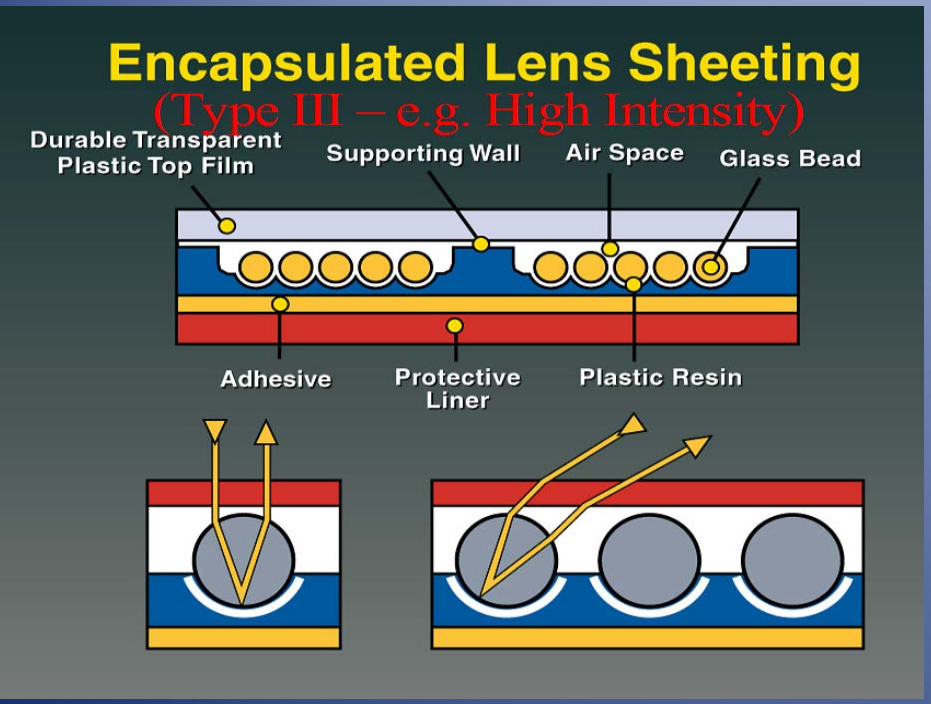

SPEED
LIMIT
35
SPEED
LIMIT
35
SPEED
LIMIT
35

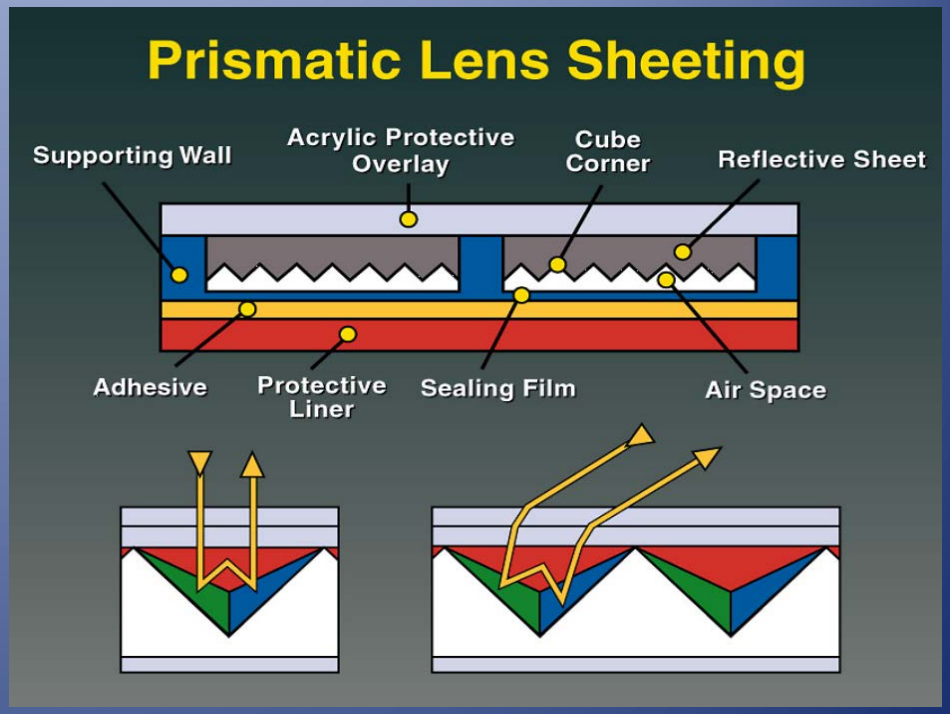
Sign Retroreflectivity Specifications

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

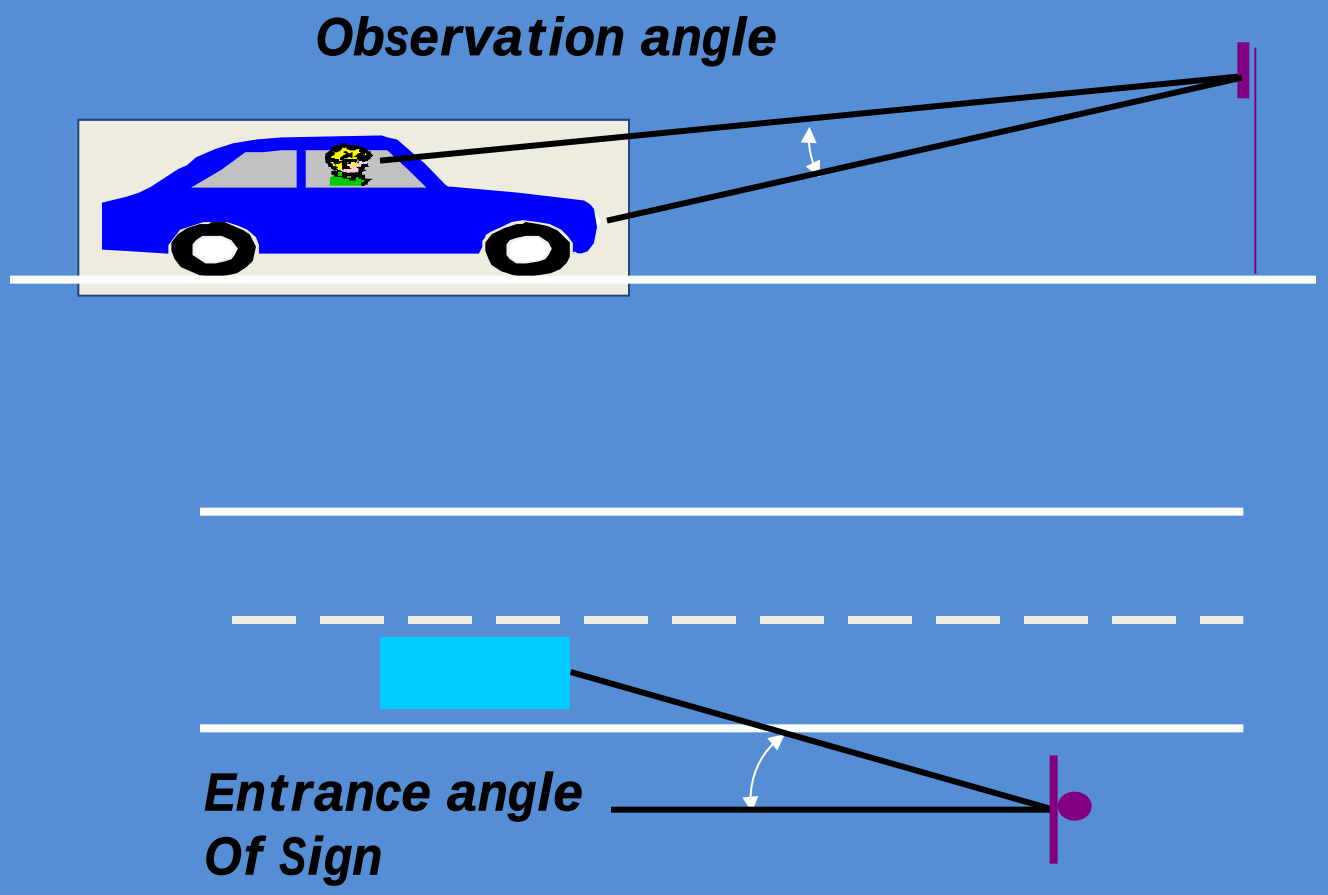
<u>Coefficient of Retroreflection, R_A</u> – the ratio of the coefficient of luminous intensity of a plane retroreflecting surface to its area expressed in candelas per lux per square meter. ($cd/lx/m^2$)

Sign Sheeting Types





Basic Angles of Ground- Mounted Sign Retroreflectivity



Portable Retroreflectometers – Different Types

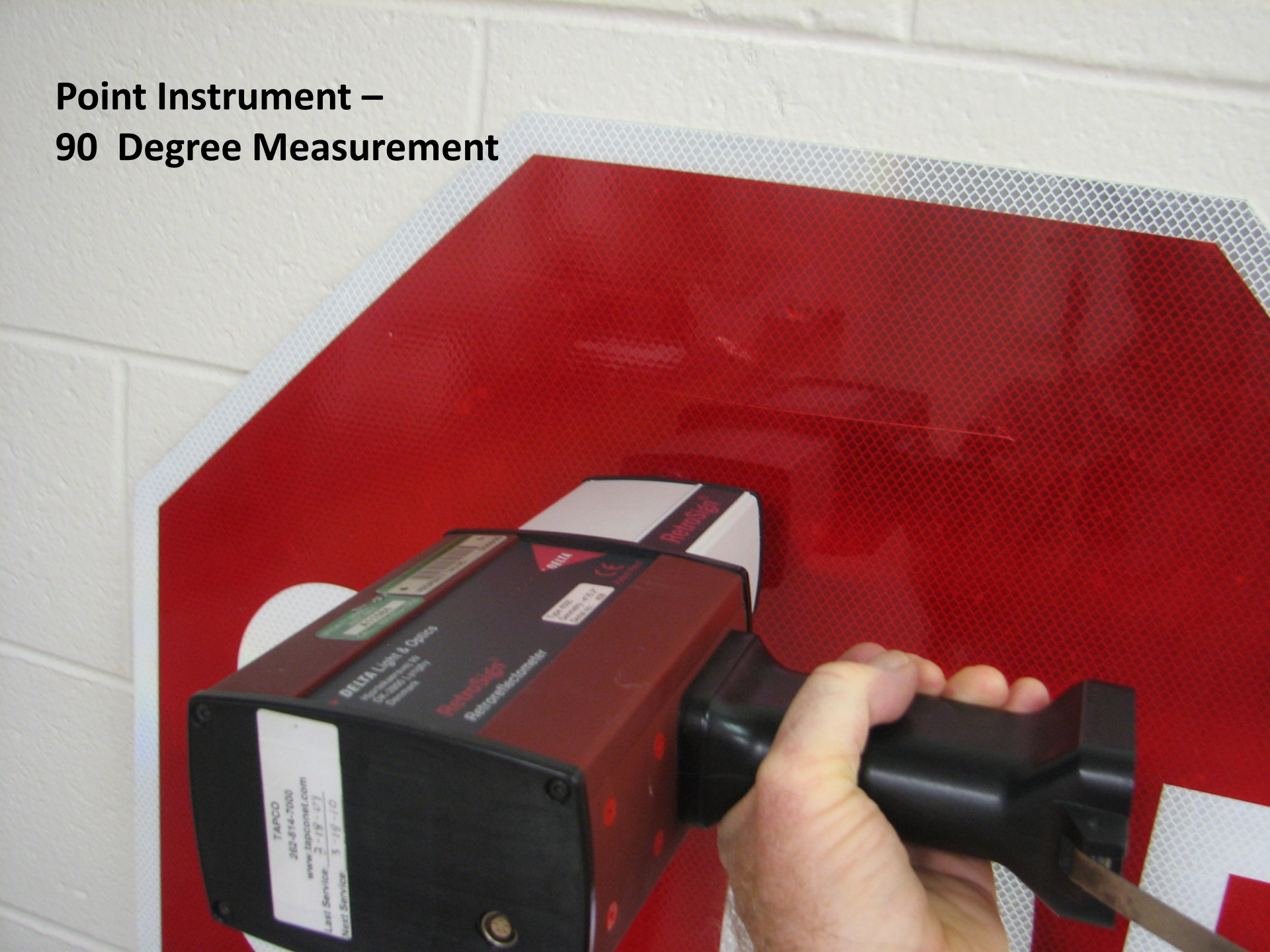
Point Instrument - has a single light detector next to the light source or axis and makes an R_A measurement virtually identical to an R_A measurement made on a lab range system where the light detector is on top of the light source. Like the motorcycle illustration. Typical R_A specifications require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

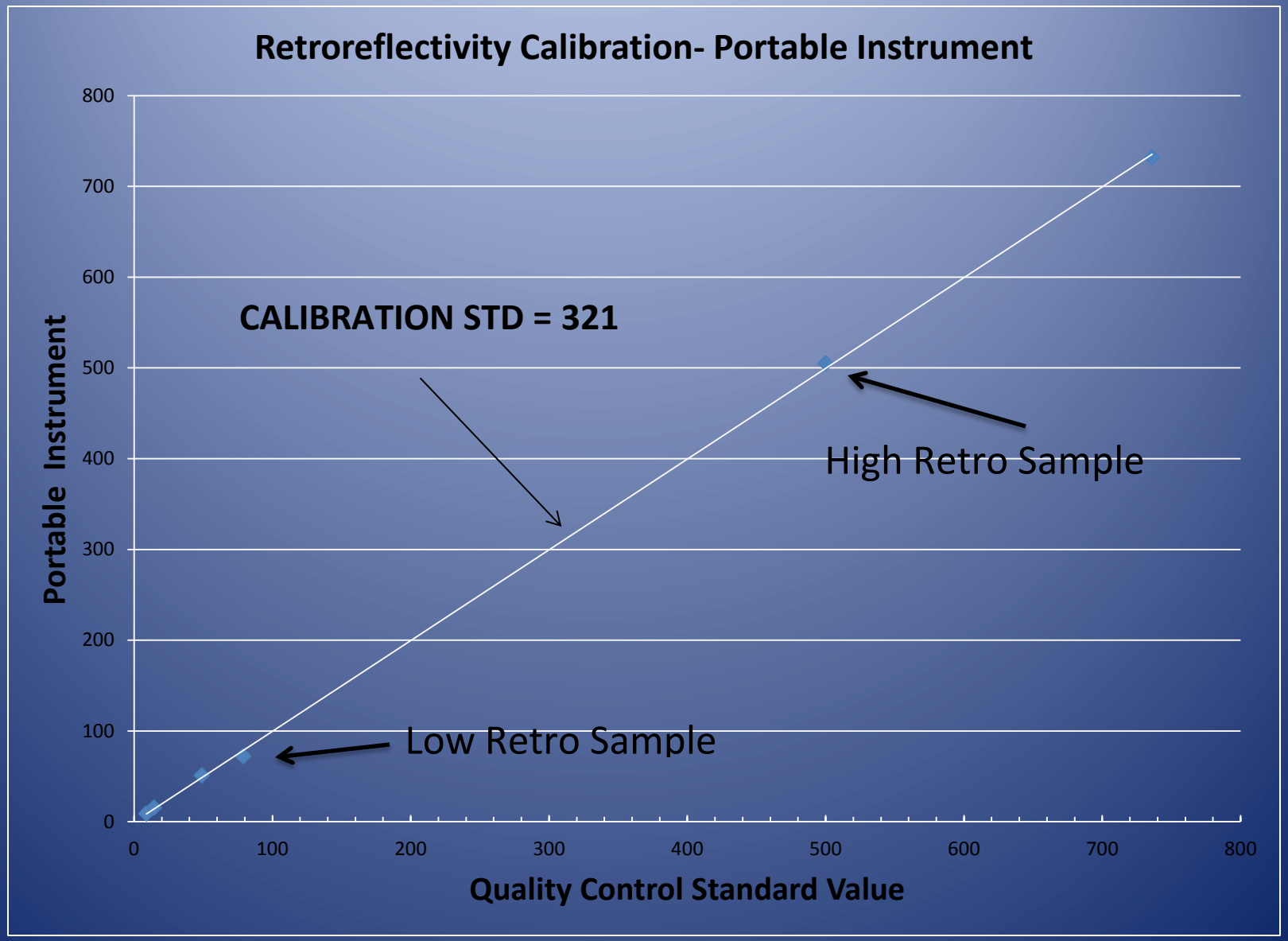
Point Instrument –
90 Degree Measurement

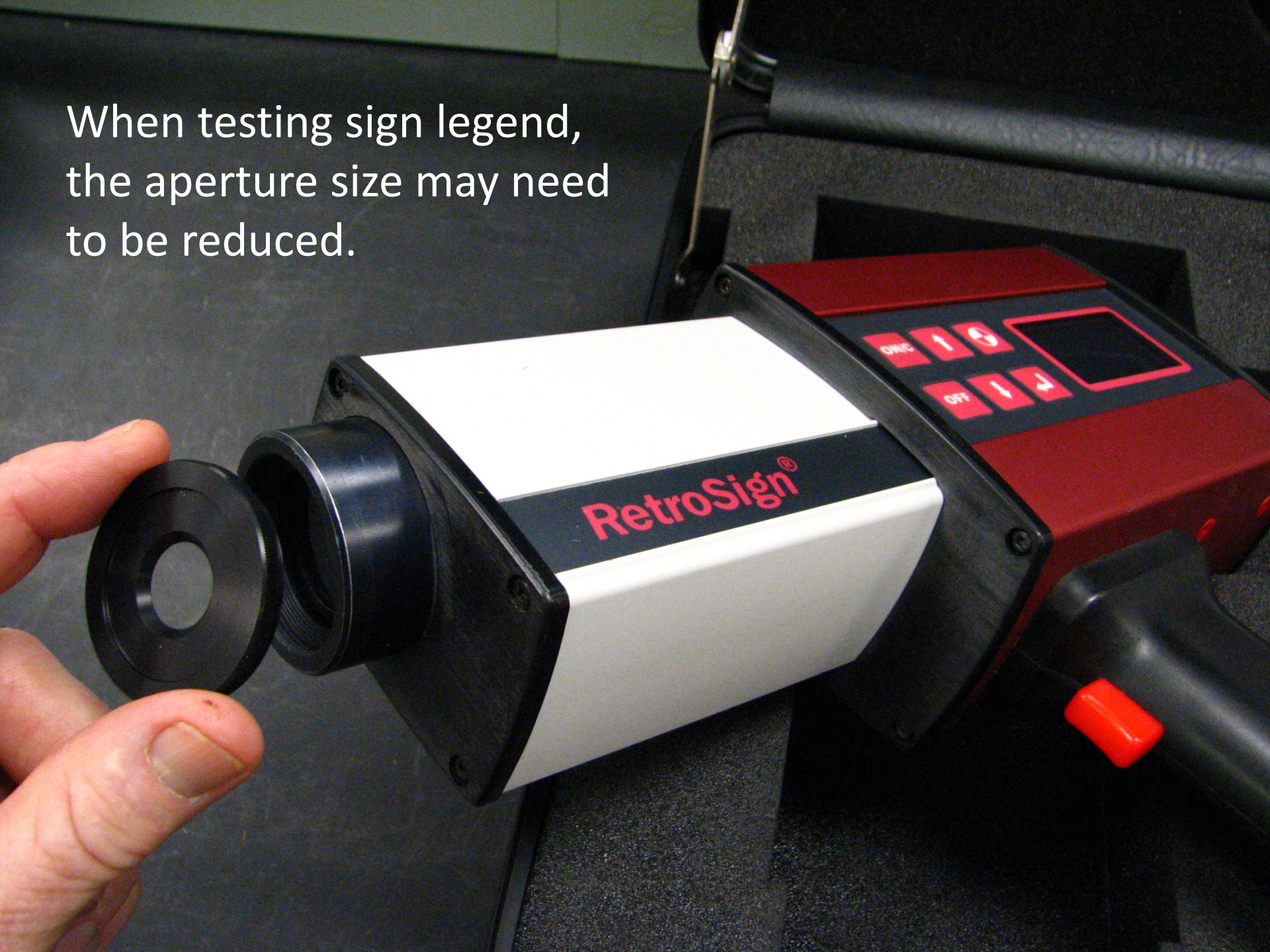


Calibrating the Instrument with Sheeting Standard = 321

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

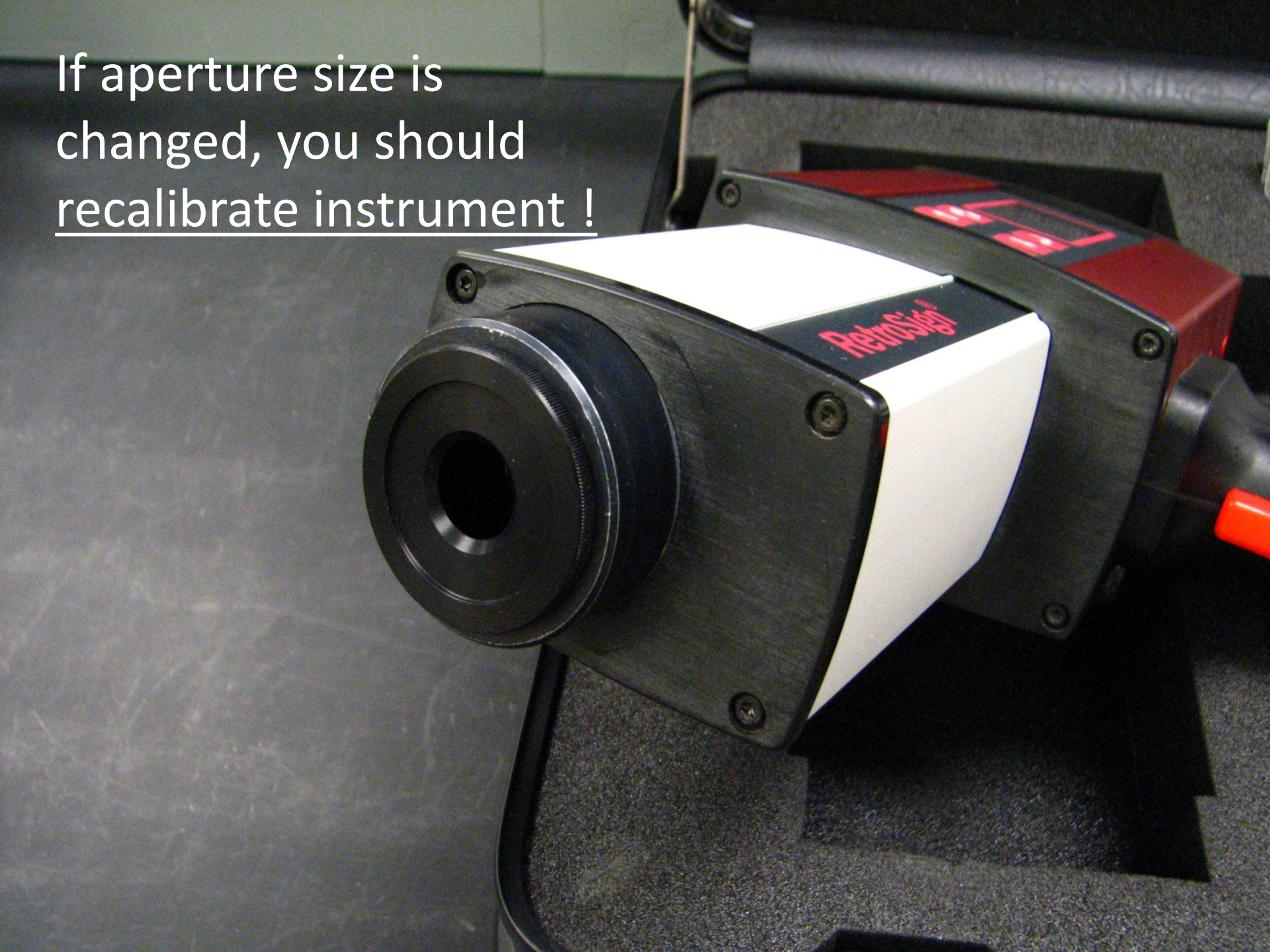
Example of testing a Quality Control sample.
(High retro value).


Retroreflectivity Calibration- Portable Instrument
CALIBRATION STD = 321
High Retro Sample
Low Retro Sample
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 <u>recalibrate instrument !</u>



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]

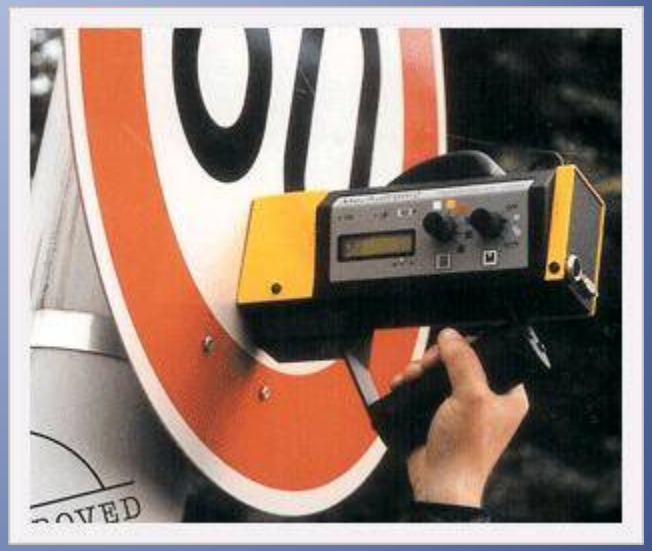
Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.1°[B]	−4°	300	200	120	54	54	24	14
0.1°[B]	+ 30°	180	120	72	32	32	14	10
0.2°	− 4°	250	170	100	45	45	20	12
0.2°	+ 30°	150	100	60	25	25	11	8.5
0.5°	−4°	95	62	30	15	15	7.5	5.0
0.5°	+ 30°	65	45	25	10	10	5.0	3.5

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

Portable Retroreflectometers

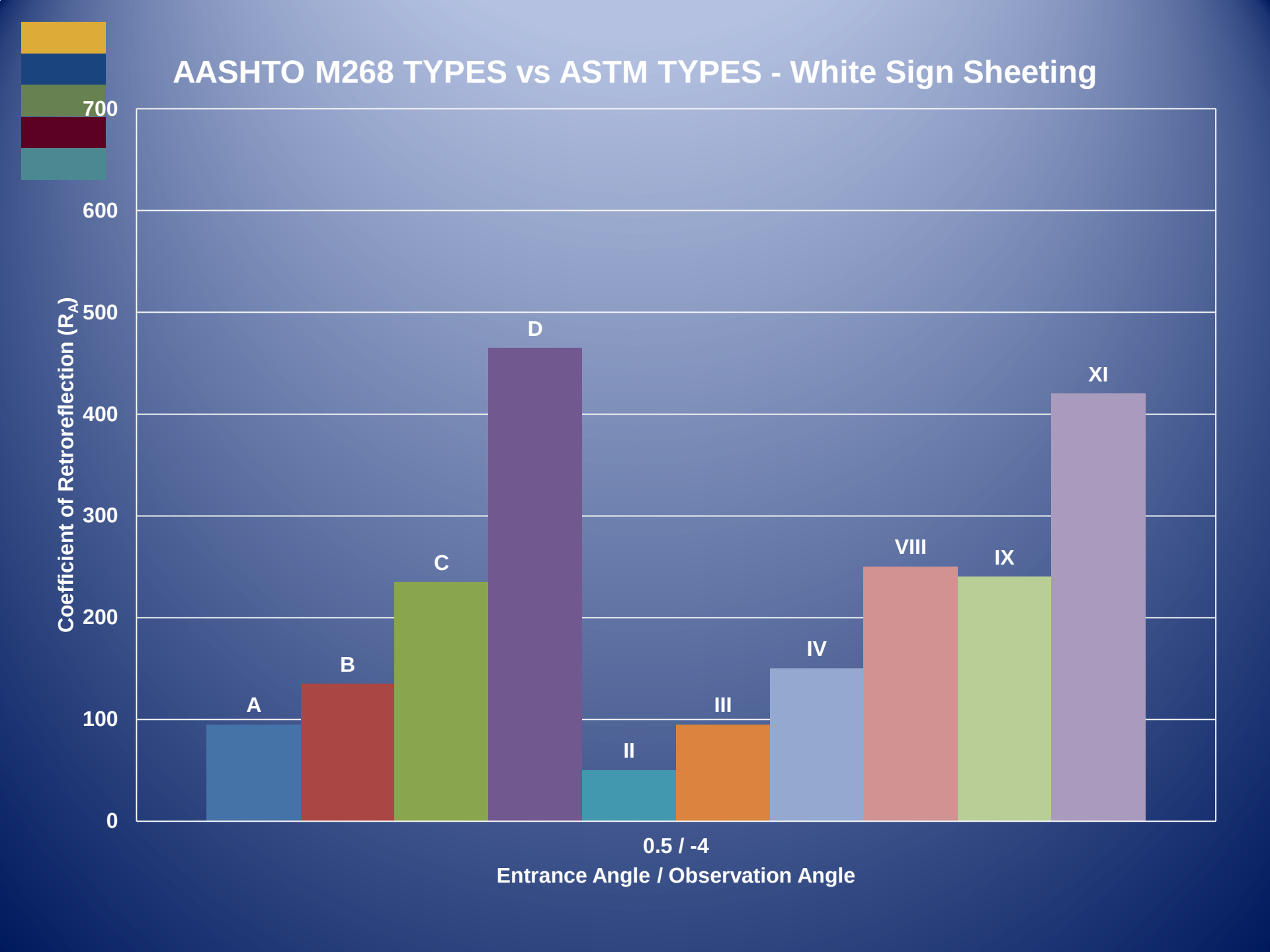
Delta
Retrosign
4500

Mechatronic
RC 2000



Zehntner 6060

Road Vista 922


AASHTO M268 TYPES vs ASTM TYPES - White Sign Sheeting
Coefficient of Retroreflection (R_A)
700
600
500
400
300
200
100
0
A
B
C
D
II
III
IV
VIII
IX
XI
0.5 / -4
Entrance Angle / Observation Angle

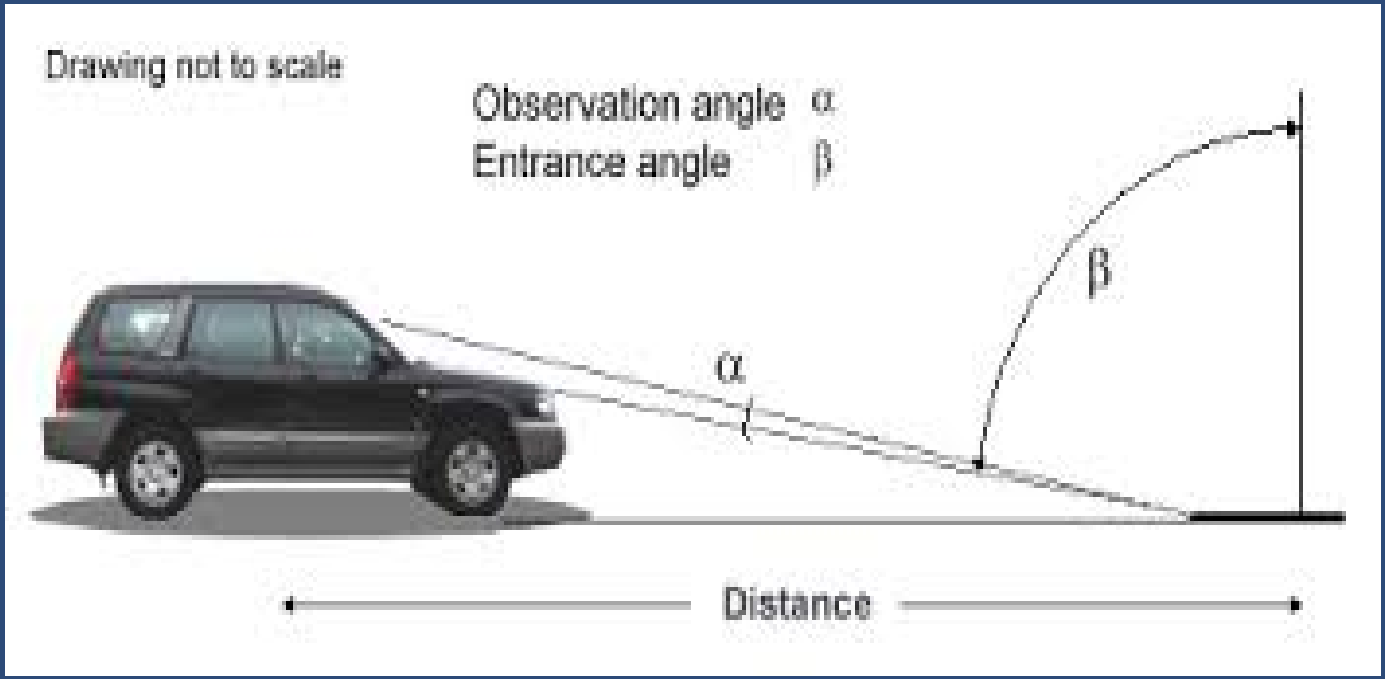
Retroreflectivity Concepts

MEASURING PAVEMENT MARKING RETROREFLECTIVITY

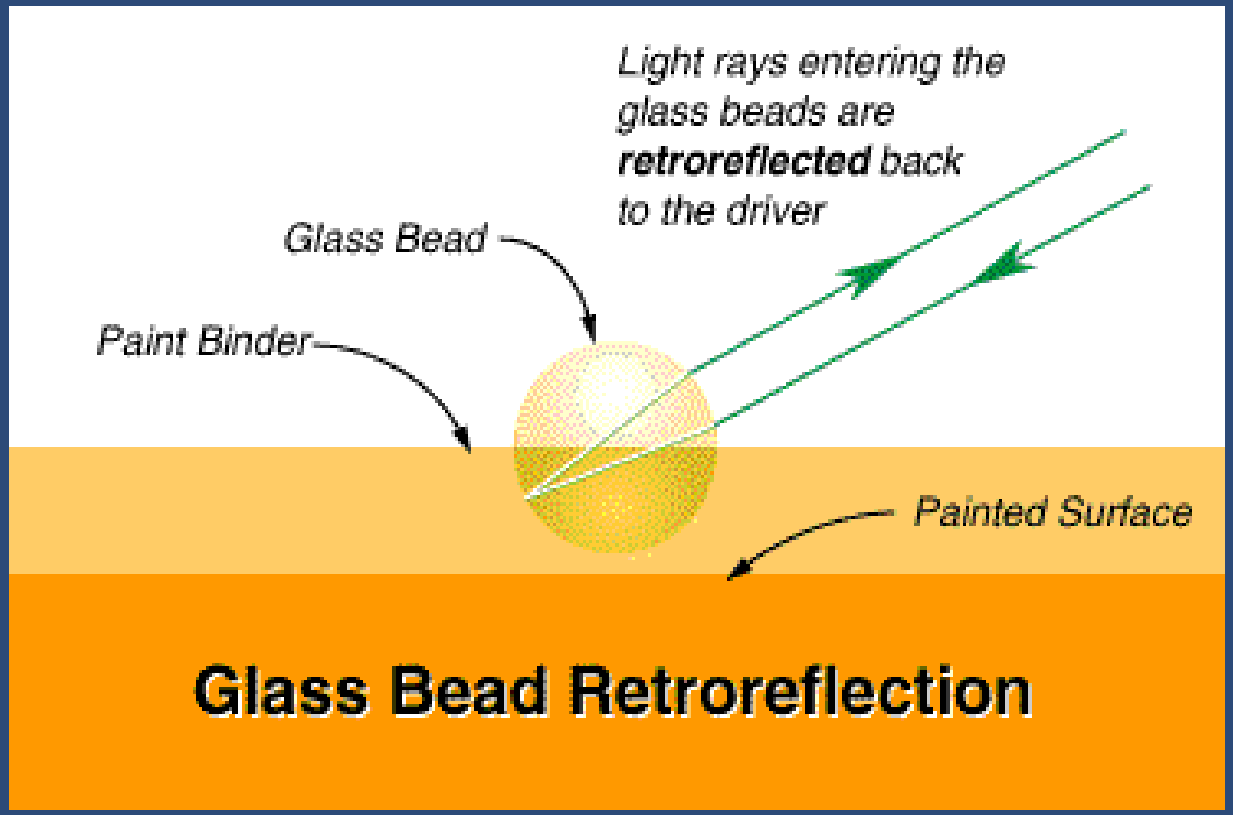
Retroreflectivity Concepts

- 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 – 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

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


Measuring dry retro of the rumble stripe.
Note: Stabilizing plate is optional.
LTL-X

New Tape
Retro = 1000mcd

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


Columbia


GDOT
ett Place

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.

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.


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

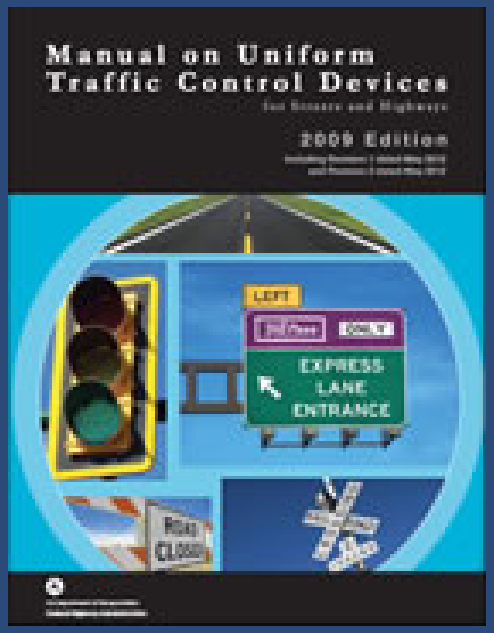
Retroreflectivity Concepts

Questions?

Minimum Sign 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 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**

Sign Types

- 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

MUTCD Assessment and Management Methods	Primary Sign Replacement Method		Secondary or Support Method	
	Local Agencies*	State DOTs	Local Agencies	State DOTs
Nighttime Inspection	6	7	0	2
Measured Retroreflectivity	2	0	0	0
Expected Sign Life	11	4	11	5
Blanket Replacement	3	5	4	0
Control Signs	2	0	5	5

*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

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

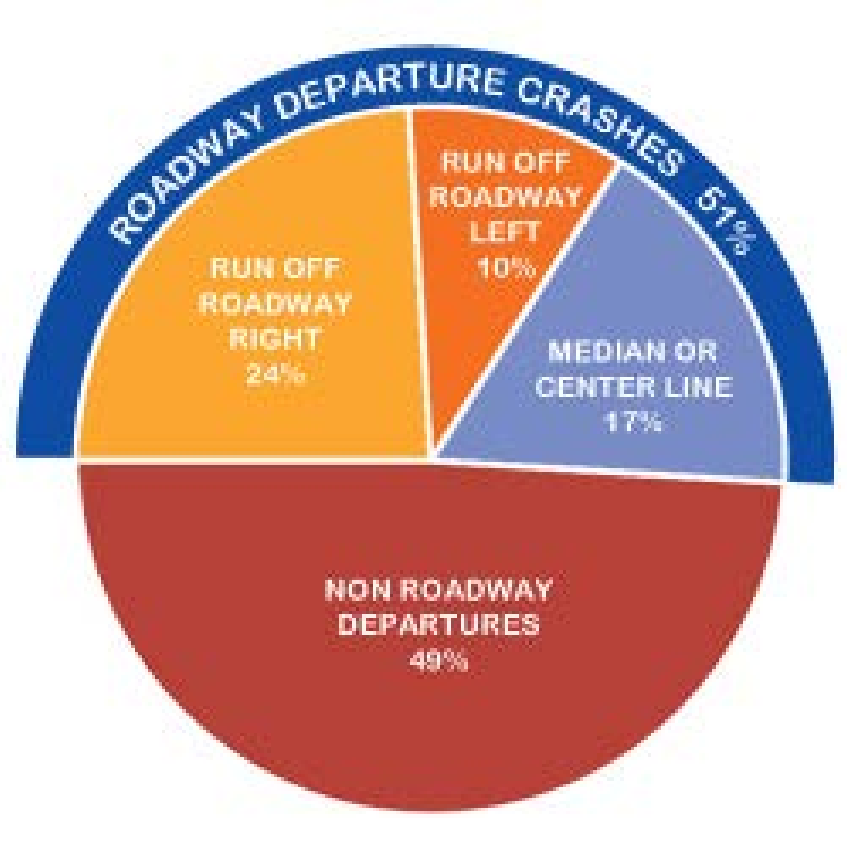
AASHTO - Survey conducted in 2014

Markings for Machines

Lane Departure Warning
Lane Keeping Assistance

Highway Safety Statistics

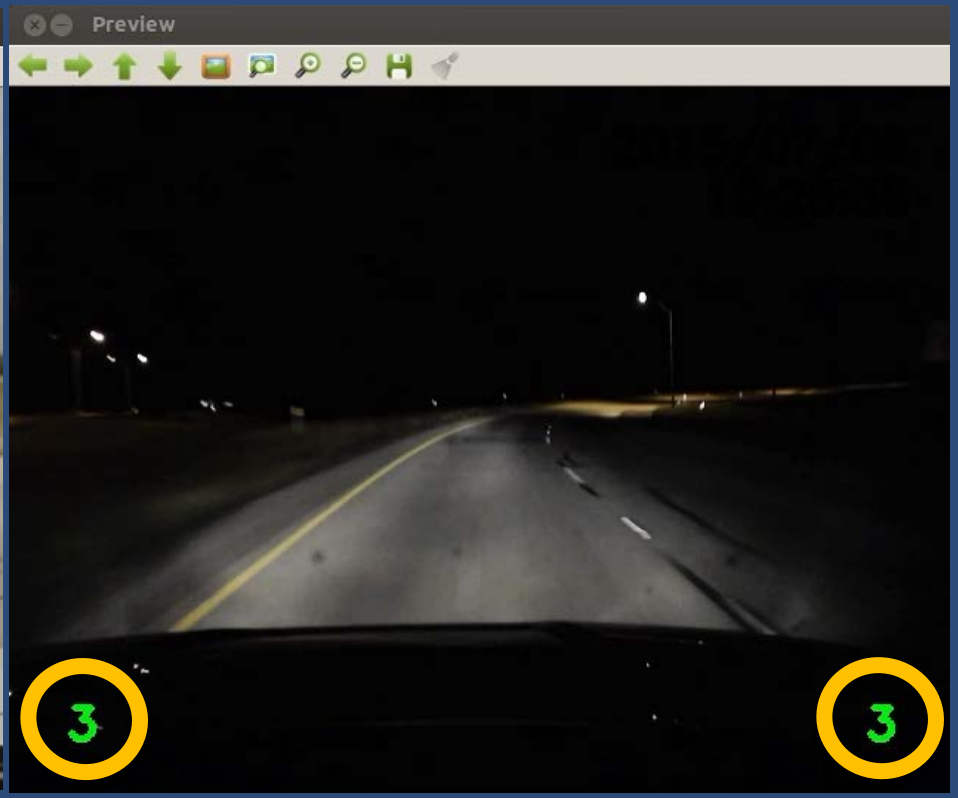
- Roadway departure crashes account for over half of all fatal crashes in the US (51%)



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

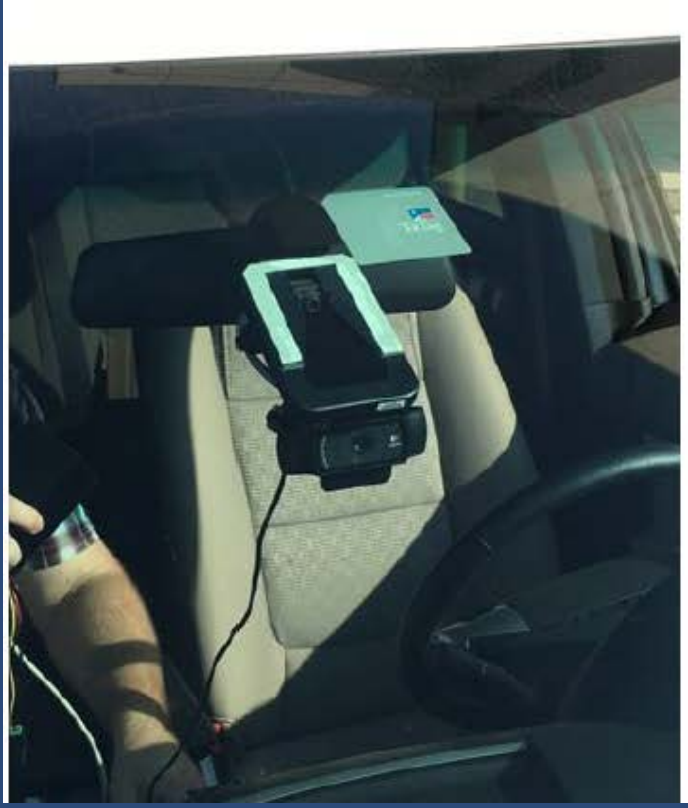


Images courtesy of TTI

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

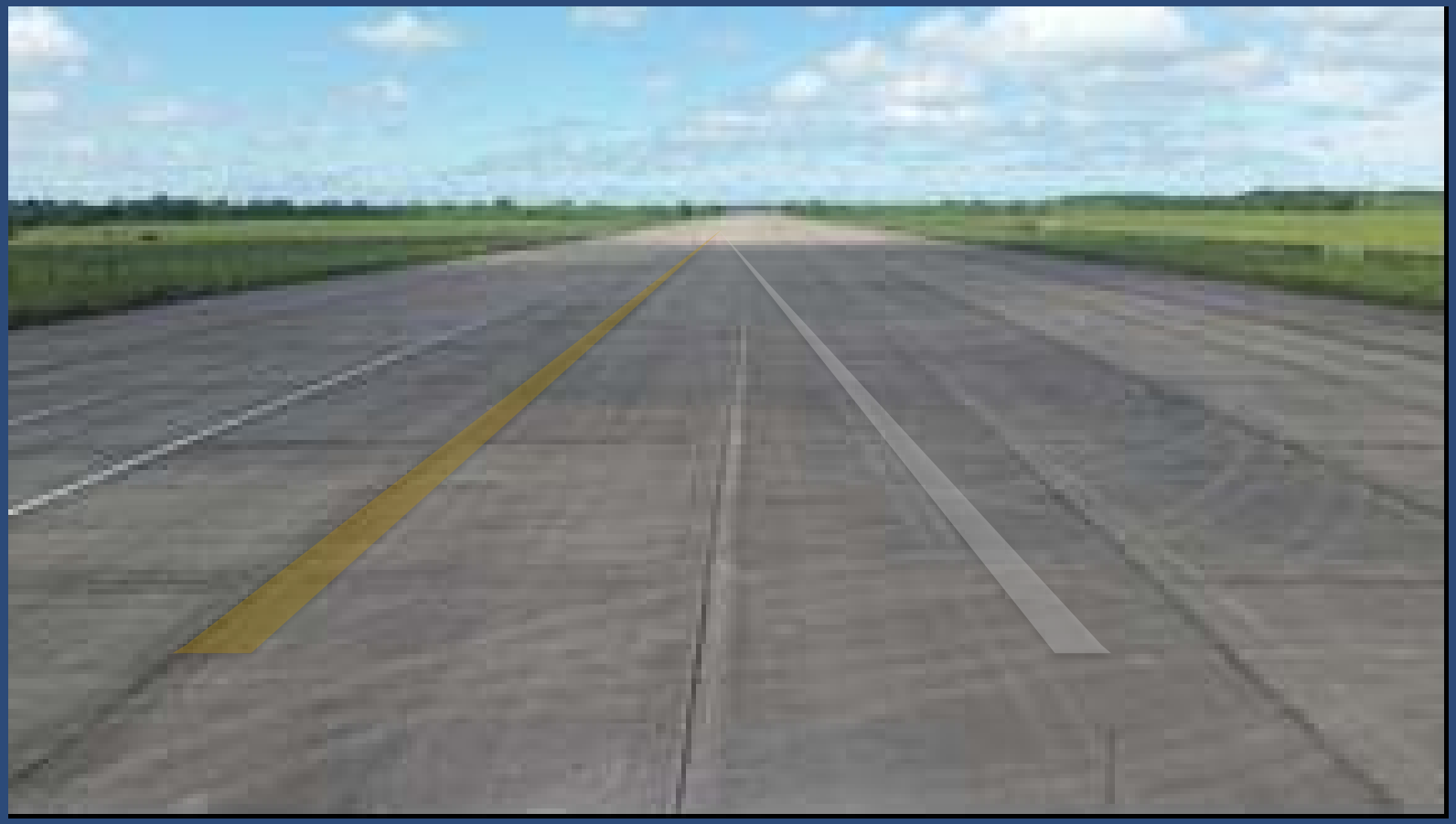
Markings (Level 1)

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)

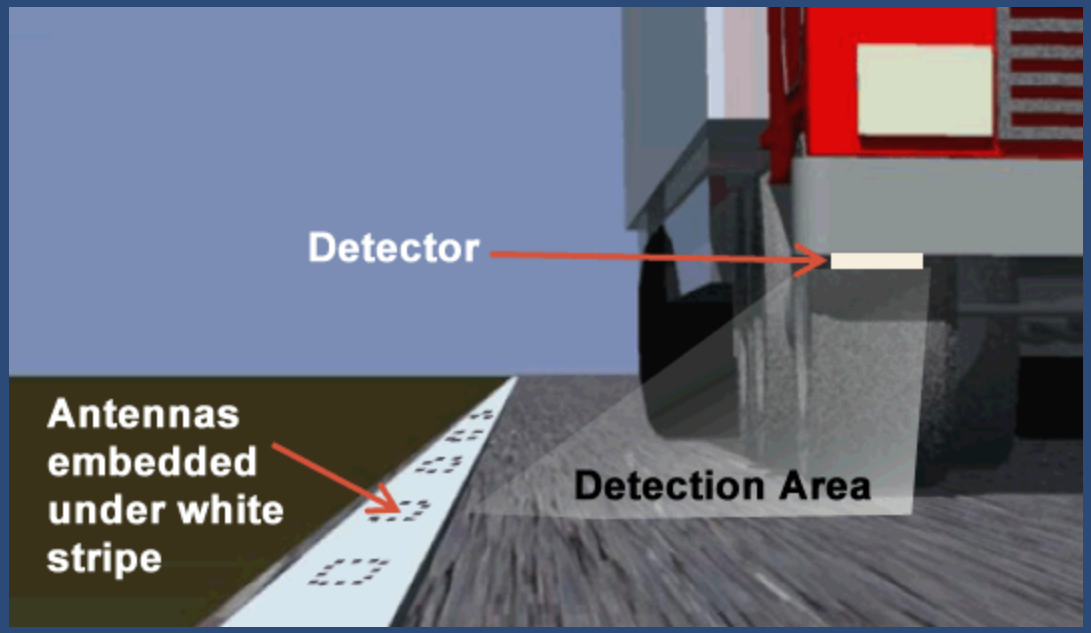
Expected Results

- 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



VDOT – VTTI – TTI