



Meeting the Minimum Requirements for Lane Line Delineation

Construction, Materials, and Alternative Delivery -
2024 Conference

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- Why are pavement markings important?
- Pavement marking requirements
- Pavement marking testing and inspection
- How does TxDOT maintain markings
- FHWA maintaining minimum retroreflectivity requirements
- How is TxDOT addressing FHWA requirement?
- Factors that can affect pavement marking quality / service life
- Key takeaways

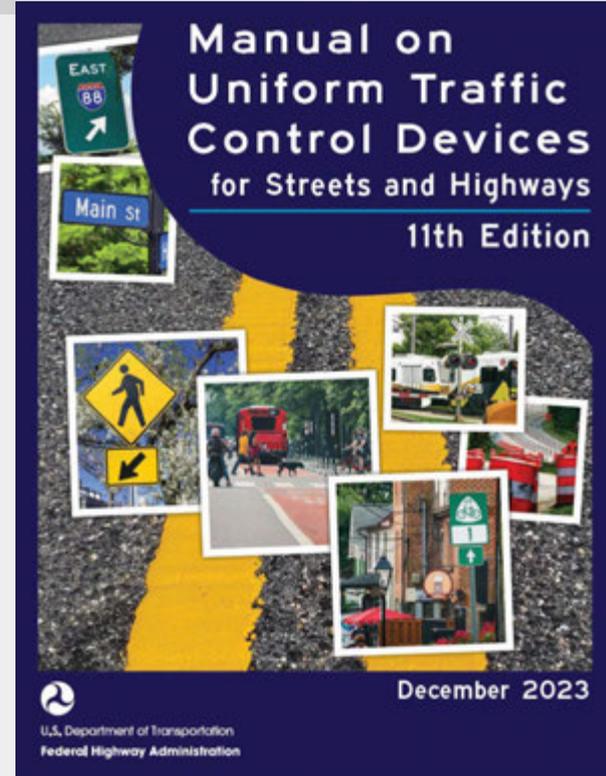
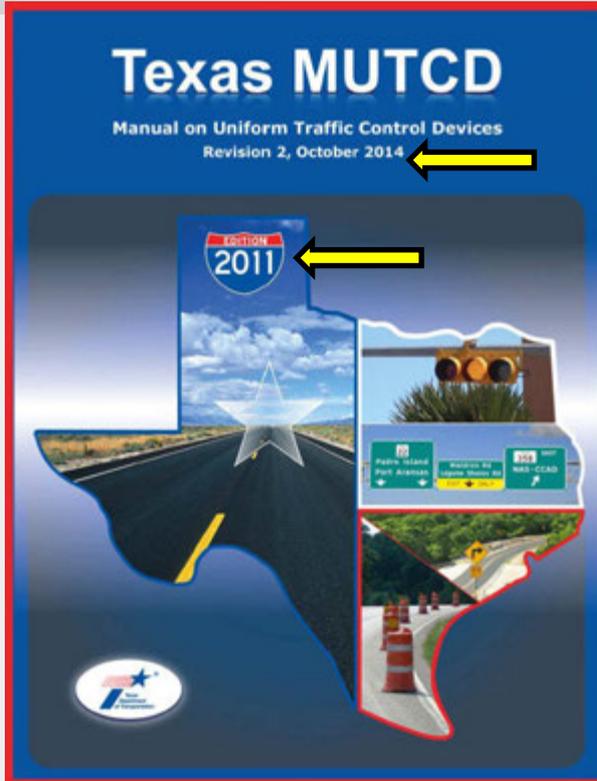
Why are Pavement Markings Important?



- Continuous delineation to keep vehicles in their lanes and provide long range guidance
- Critical for drivers and newer driver assistance systems like lane centering
- Day visibility – presence/contrast
- Night visibility – presence/retroreflectivity
- FHWA indicates nighttime fatal crash rate is 3x that of daytime
- Wet-night visibility is always a major complaint of drivers (need well maintained markings and RPMs)
- RPMs are used to supplement markings to provide added nighttime visibility, especially wet-night.



Pavement Marking Requirements

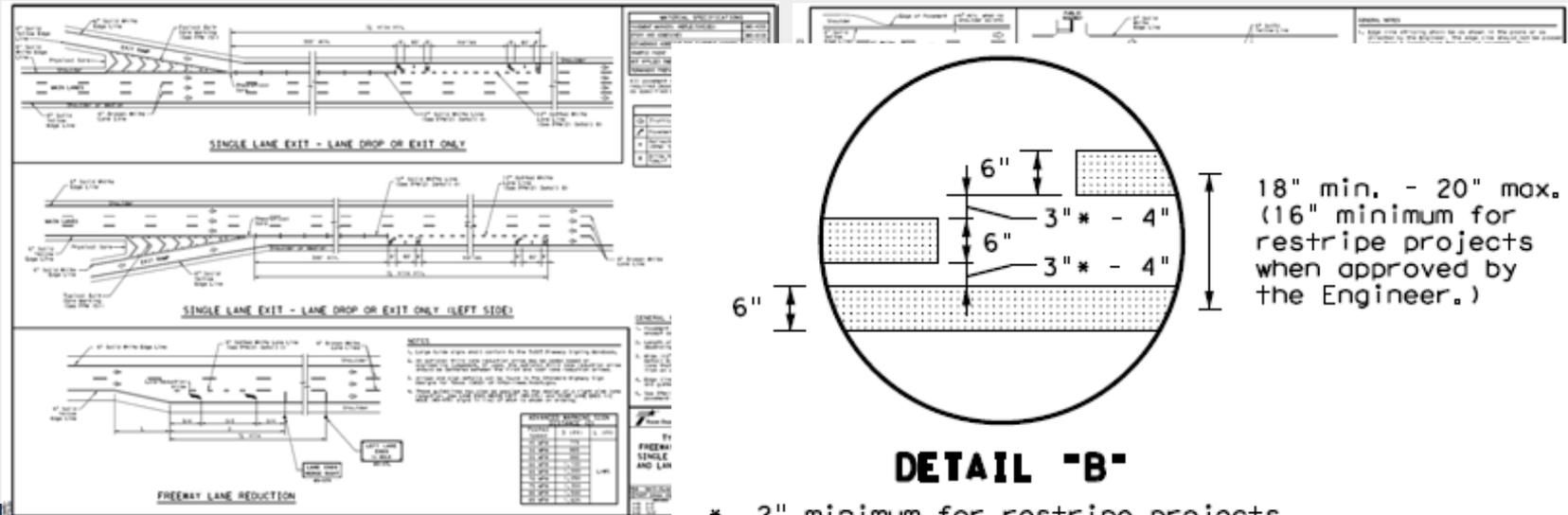


- TxDOT has 2 years to adopt the 11th Edition of the MUTCD or to update the Texas MUTCD to be in substantial conformance to the National MUTCD

Pavement Marking Requirements



- Traffic Safety Division Standard Sheets
 - Can be found at: dot.state.tx.us/insdtdot/orgchart/cmd/cserve/standard/toc.htm
 - Changed to all 6-inch-wide normal markings in 2022



Pavement Marking Requirements



- Benefit of moving to 6-inch markings
 - 6-inch wider markings have **visibility and conspicuity benefits** that have resulted in documented safety benefits
 - **Potential durability** improvements due to more material on the road
 - **Drivers prefer** wider markings
- Can get exceptions to use 4-inch?
 - Potential liability of using less than standard design





2024 Specifications

666

Item 666

Retroreflectorized Pavement Markings



- Major changes with 2024 spec book rewrite
 - Inclusion of Type III PMM: Multipolymer markings*
 - Inclusion of Type I high-performance thermoplastic markings*
 - Inclusion of Type I, II, and III all-weather markings*
 - Added retroreflectivity requirements for Type I profile markings and Type II PMM (paint).
 - Typical retroreflectivity measurements at 10-30 days after application compared to 3-10 days previously. Sealcoat roads are still 3-10 days.
 - High-performance and wet-retroreflectivity are measured at 30-60 days.

* = previously a special specification



Item 666

Retroreflectorized Pavement Markings



- Initial Retroreflectivity Requirements

Marking Type	White	Yellow	Marking Type	White	Yellow
Type I (including profile)	250	175	Type II	175	125
Type I High-performance	400	250	Type II All-weather (dry/wet)	250/100	150/75
Type I All-weather (dry/wet)	400/150	250/125	Type III	400	250
Retroreflectivity values in mcd/m ² /lux			Type III All-weather (dry/wet)	400/150	250/125

- Initial retroreflectivity requirements are needed for
 - Nighttime visibility and overall marking durability
 - Need to remain visible during its life (New FHWA Maintenance Requirements)



Item 666

Retroreflectorized Pavement Markings



- Material thickness requirements

Marking Type	Thickness	Notes	Marking Type	Thickness	Notes
Type I	100 mil	Seal coat (new)	Type II	30 gal/mile	concrete and asphalt
Type I	60 mil	Retrace over thermoplastic	Type II	33 gal /mile	seal coat
Type I	90 mil	All other application	Type II	22.5 gal/mile	minimum for sealer
Type I Profile	90 mil	Minimum (flat portion)	Type II All-weather	25 mil wet	minimum thickness
Type I Profile	300-410 mil	Profile (not including base)	Type III	manufacturers recommendation	
Type I All-weather	100 mil	minimum thickness			

- Thickness requirements are needed for
 - Proper embedment of reflective optics (beads and elements, etc.)
 - Overall marking durability

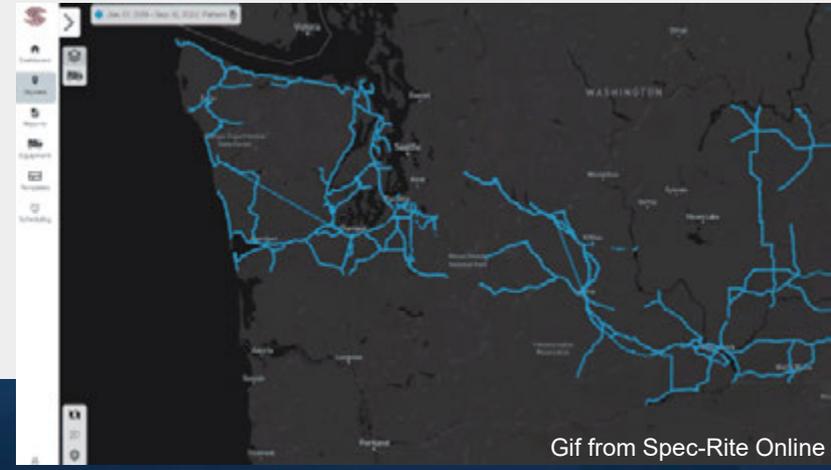


- 2024 standard specifications are posted and must be used on projects letting beginning September 2024.
- Other Special Specifications (numbers changing with 2024 spec rewrite)
 - 6019 – Prefabricated Pavement Markings with Warranty
 - 6020 – Multipolymer Pavement Markings with Warranty
 - 6373 – All-Weather Patterned Thermoplastic
 - 6439 – High Performance Pavement Markings – Ribbon
 - Performance Based Maintenance (OTU or CSJ based)
 - Pavement marking material application data logging (Previously Special Provision 666-009)
 - Includes use of a computerized data logging system to monitor vehicle speed, material usage, and application conditions
 - Some issues with data logging right now: paint systems are reliable, but thermoplastic is not as reliable, work in this area is on-going.

Pavement Marking Data Logging



- Data logging is a good means to monitor pavement marking applications when an inspector cannot be continuously present at the job site.
- Track application areas and material usage to make sure the correct thickness is being applied.
- Develop maps of marking installations
- Data can be used as part of a system to monitor service life of the markings





- Departmental Material Specifications (DMS)
 - DMS-4200 Pavement Markers (Reflectorized)
 - DMS-4210 Snowplowable Pavement Markers
 - DMS-4300 Traffic Buttons
 - DMS-8200 Traffic Paint
 - DMS-8220 Hot Applied Thermoplastic
 - DMS-8230 Multipolymer Pavement Markings **New!**
 - DMS-8290 Glass Traffic Beads
 - DMS-8240 Permanent Prefabricated Pavement Markings
 - DMS-8241 Temporary Removable, Prefabricated Pavement Markings
 - DMS-8242 Temporary Flexible, Reflective Roadway Marker Tabs
- These DMS documents are currently being reviewed and revised
- Each of these materials has an approved material producer list (MPL)

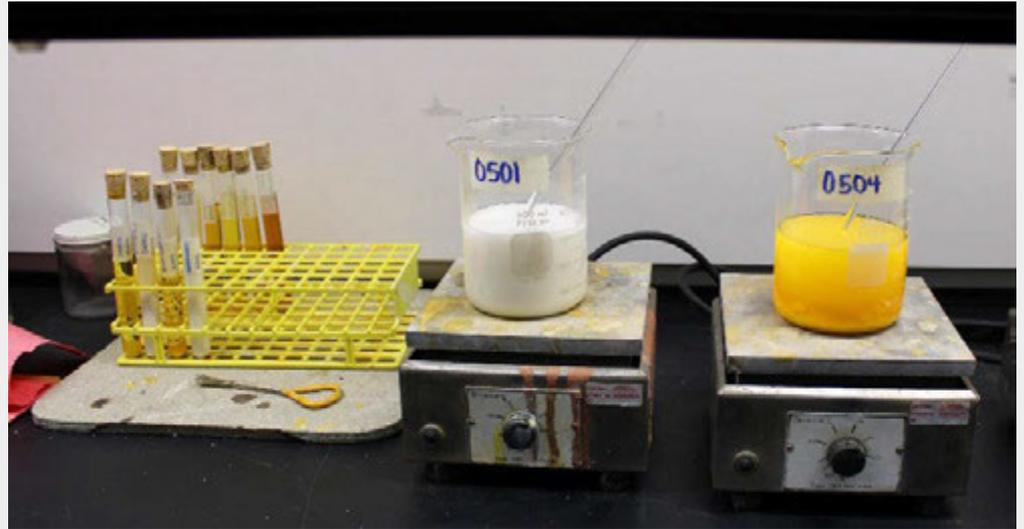


- MTD conducts field and lab tests of marking and marker materials





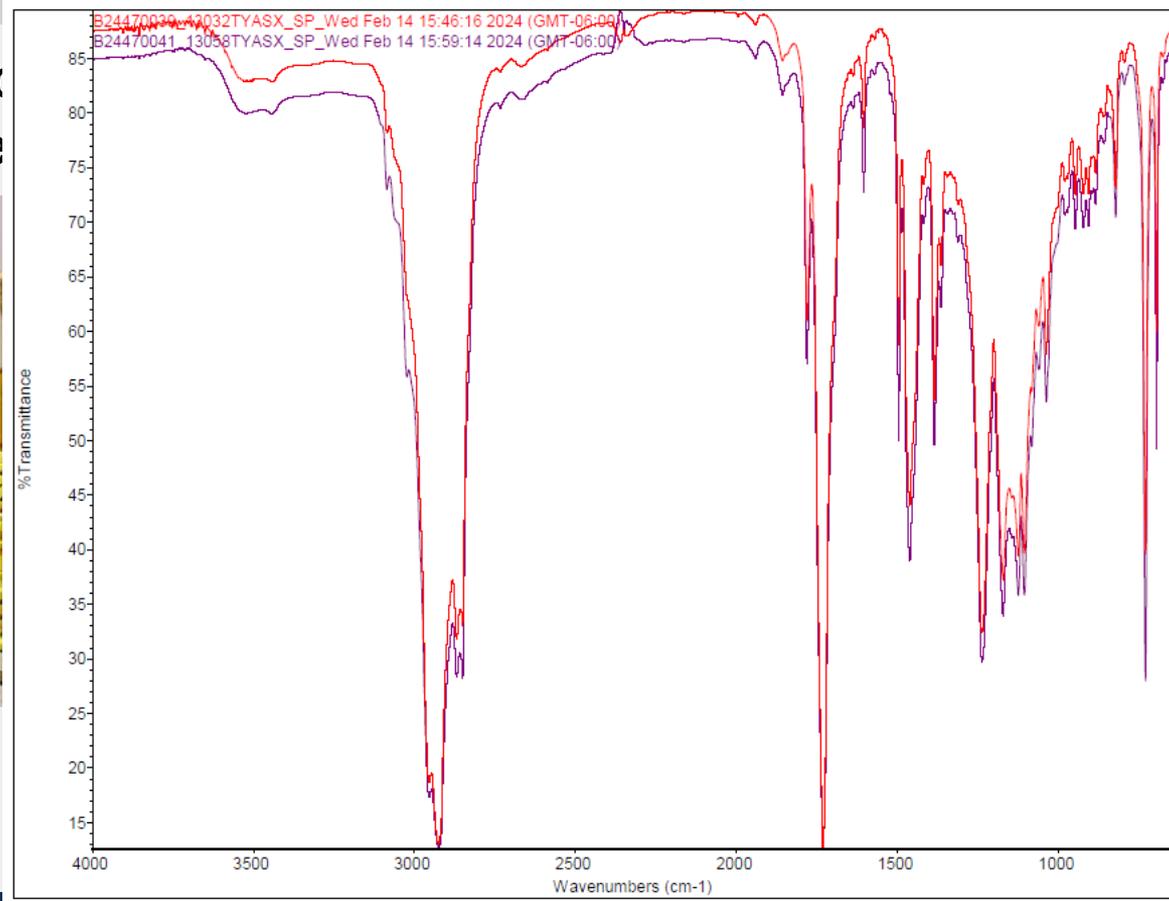
Thermoplastic Compositional Analyses



MTD – Lab Testing



Thermoplastic
FTIR- Finge



Yellow Thermoplastic

April 16, 2024

MTD – Lab Testing



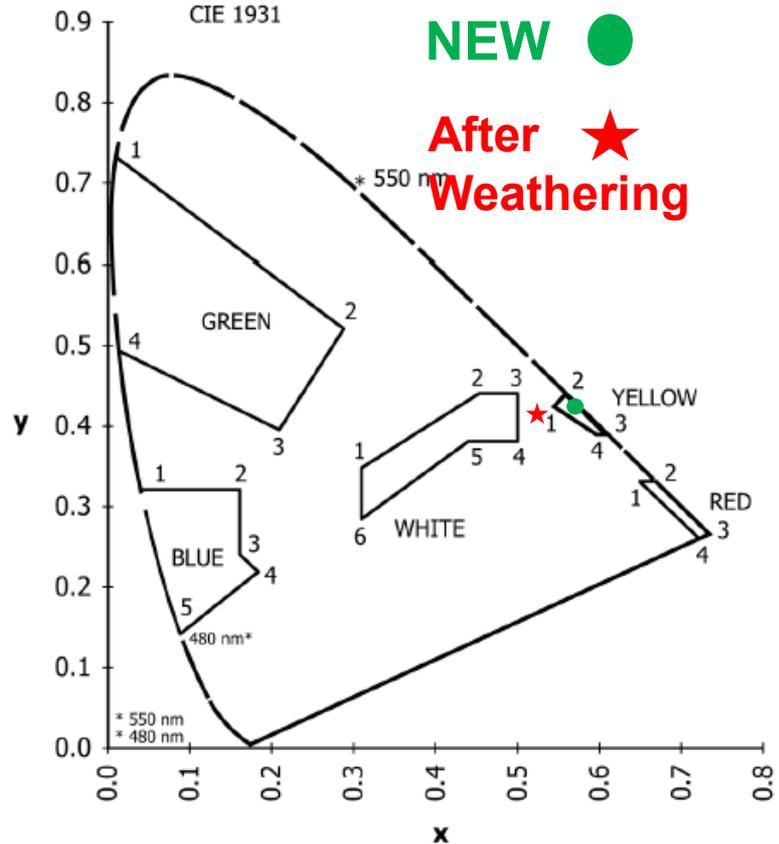
Thermoplastic Weathering



**After
Weathering**



NEW



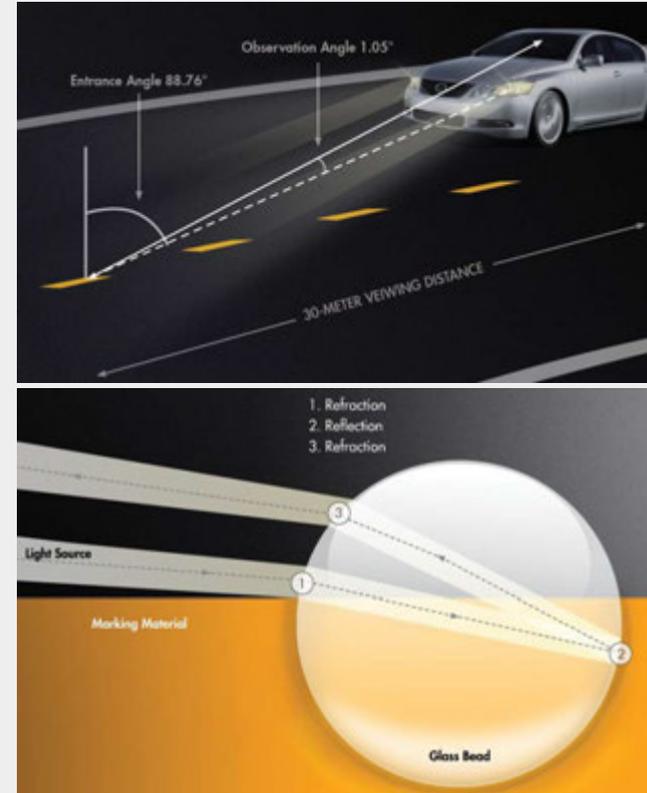


Retroreflectivity and Visibility

- Clarity
- Roundness
- Size and gradation

Following **DMS 8290** & **AASHTO M247**, beads shall be

- transparent, clean, colorless glass,
- smooth and spherically shaped,
- free from milkiness, pits, or excessive air bubbles.





Assessment of required clarity using a Color Spectrometer

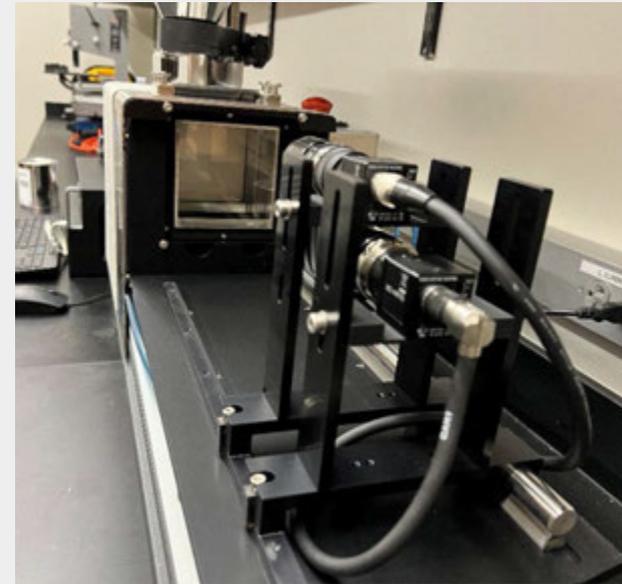


TEX-823-B: Color Measurement of Glass Beads
Federal Test Method Standard 141, Method 4252.

MTD – Lab Testing – Checking for Shape and Gradation



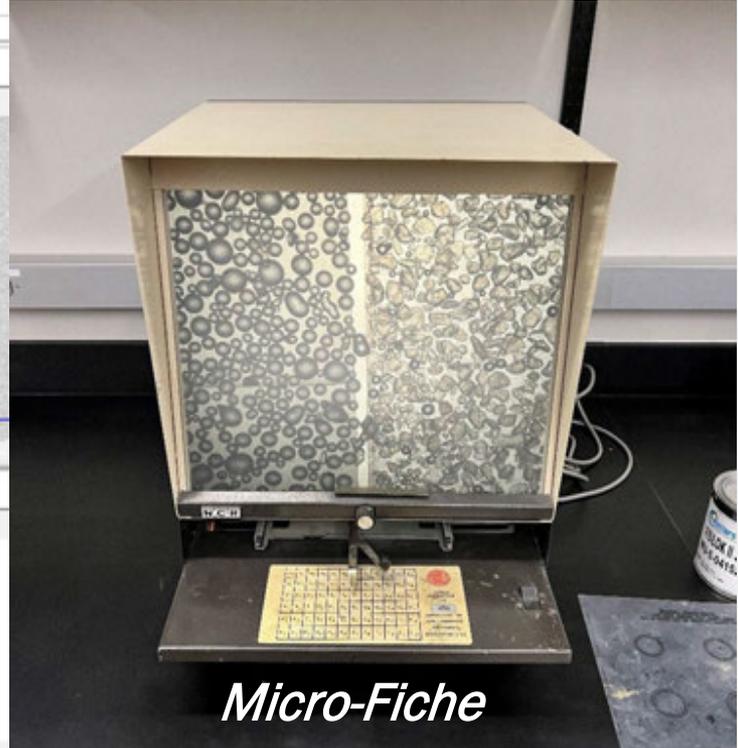
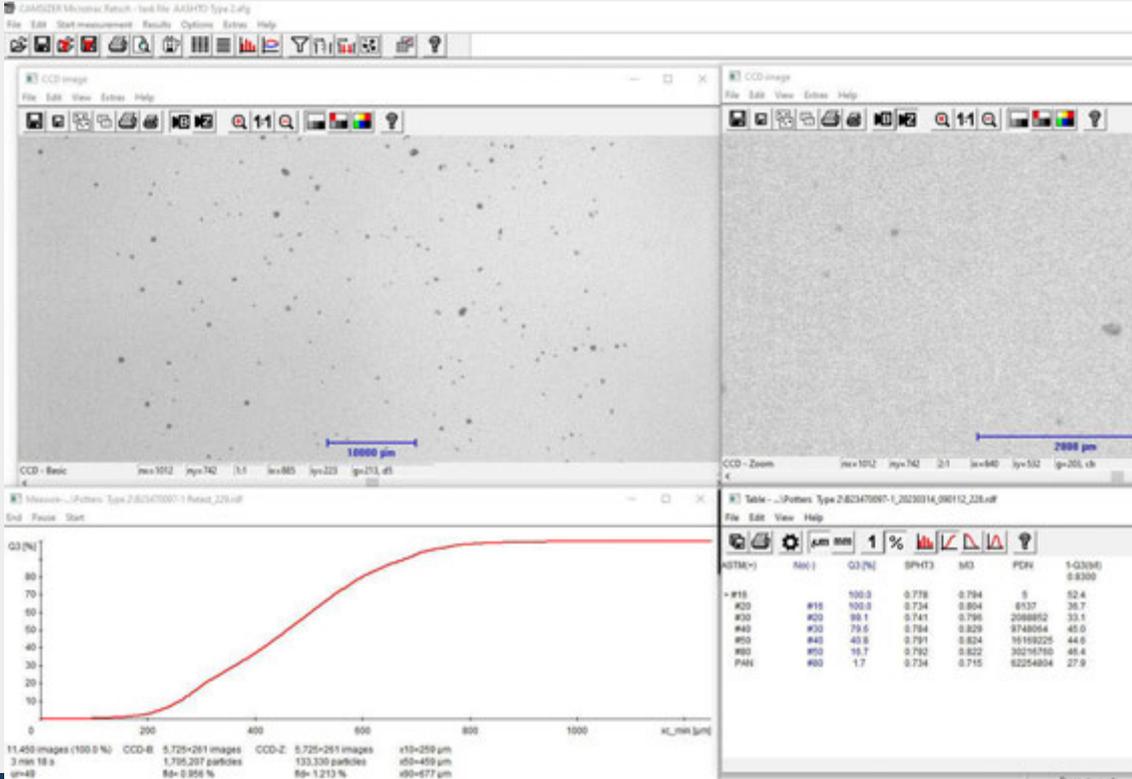
Assessment of required Shape and Gradation using Image Analyses Techniques



MTD – Lab Testing – Checking for Shape and Gradation



Assessment of required Shape and Gradation using Image Analyses Techniques

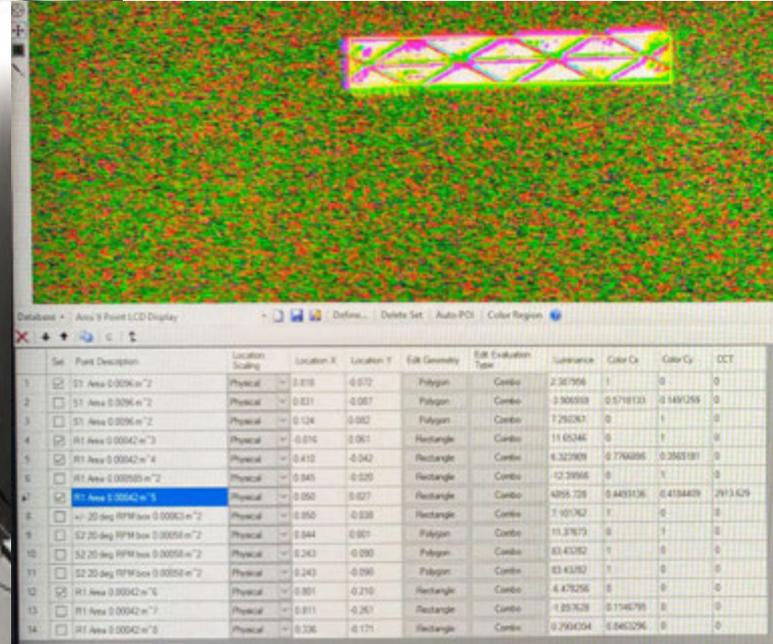


Micro-Fiche

MTD – Lab Testing – Retroreflectivity



Measuring Retroreflectivity

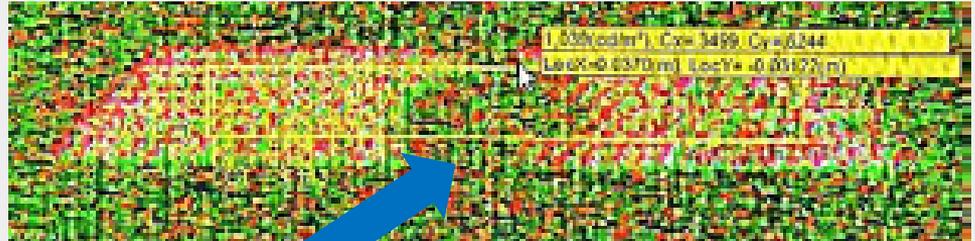


MTD – Lab Testing – Retroreflectivity



RPMs Must Meet Minimum Retroreflectivity for Road Delineation and Wet Weather Safety

Nonuniform Reflective Areas
(Dark Patches)



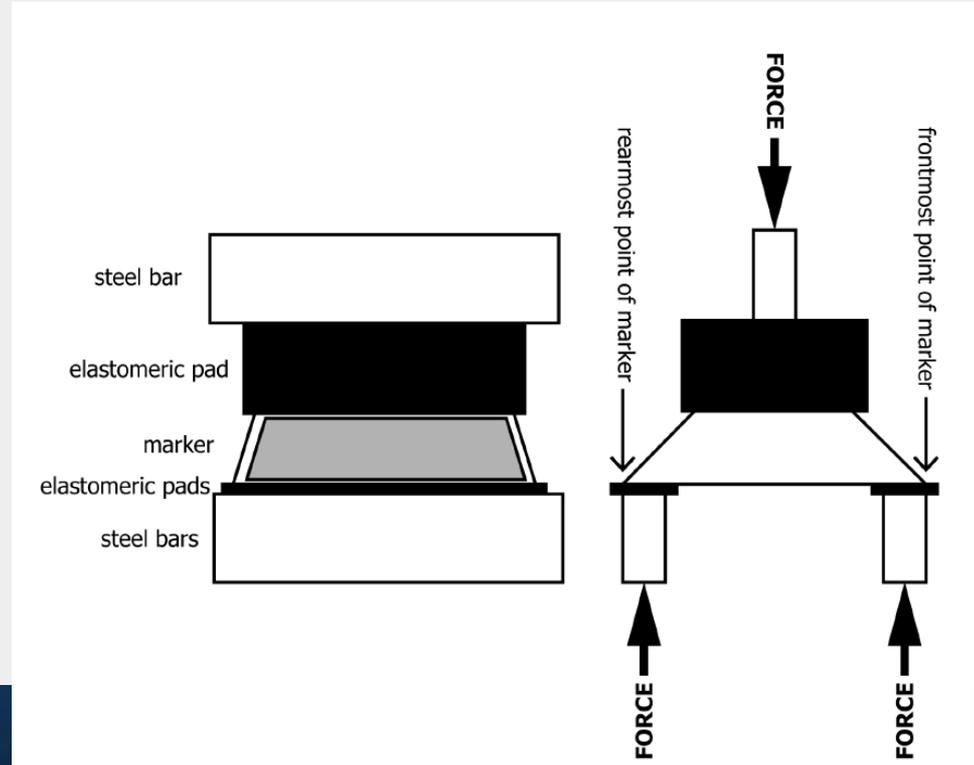


RPM – Strength Tests

Compression



Flexural



MTD – Lab Testing – RPM



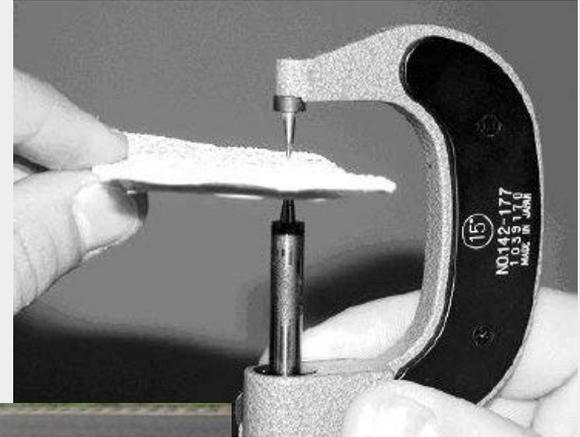
RPM – Seal Test



Pavement Marking Testing and Inspection



- Inspectors should monitor installations to ensure the requirements of Item 666 are met:
 - Proper installation conditions (weather, etc.)
 - Proper surface preparation (if needed)
 - Determining Thickness of Thermoplastic Stripe
 - Thickness by material usage
 - Thickness by measurement
 - Initial retroreflectivity
 - Handheld retroreflectometer
 - Mobile retroreflectometer



Pavement Marking Testing and Inspection



- Initial Performance (Retroreflectivity)
 - Requirements in Item 666
 - Small contracts <20,000 total feet of markings, callout work, and work zone markings do not require retroreflectivity measurements.
 - Special Specification 6438 “Mobile Retroreflectivity Data Collection for Pavement Markings” use for mobile measurements. Soon to be Item 667.
 - **Contractor Measurements** – *operator and equipment must be certified by TTI*, engineer needs to make sure the contractor is on the certified list.
 - <https://visibility.tti.tamu.edu/programs-and-guidance/mobile-retro-certification/certified-providers/>

The screenshot shows the TTI Visibility Research website. The header includes the Texas A&M Transportation Institute logo and the text 'TTI Visibility Research'. A navigation menu contains links for 'About', 'Research Areas', 'Projects', 'Publications', 'Facilities', 'People', and 'News'. The main content area features a dark red box with the text 'MOBILE RETROREFLECTOMETER CERTIFICATION PROGRAM' and two links: 'About Certification' and 'Certified Providers'. Below this is a breadcrumb trail: 'Home » Programs and Guidance » Mobile Retroreflectometer Certification Program » Certified Providers'. The title 'Certified Providers' is displayed in a large font. At the bottom, a table header is visible with columns: 'Provider', 'Operator', 'Certified Period*', and 'Equipment (serial number)'.

Pavement Marking Testing and Inspection



- SS 6438/ Item 667 Mobile Retroreflectivity Data Collection for Pavement Markings
 - Describes measurement process and requirements to meet the retroreflectivity requirements in Item 666
- Generates spreadsheet data, a map of the data, and a video of the data collection with data overlay

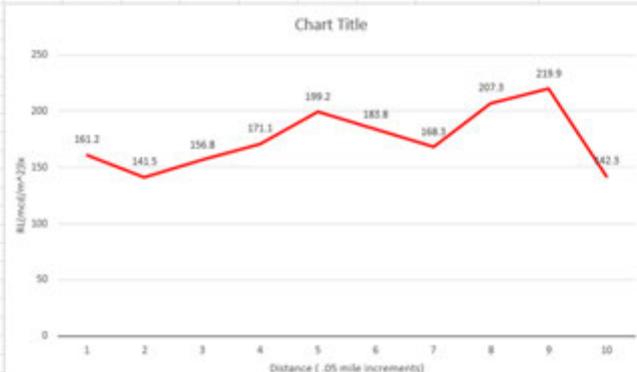


Pavement Marking Testing and Inspection



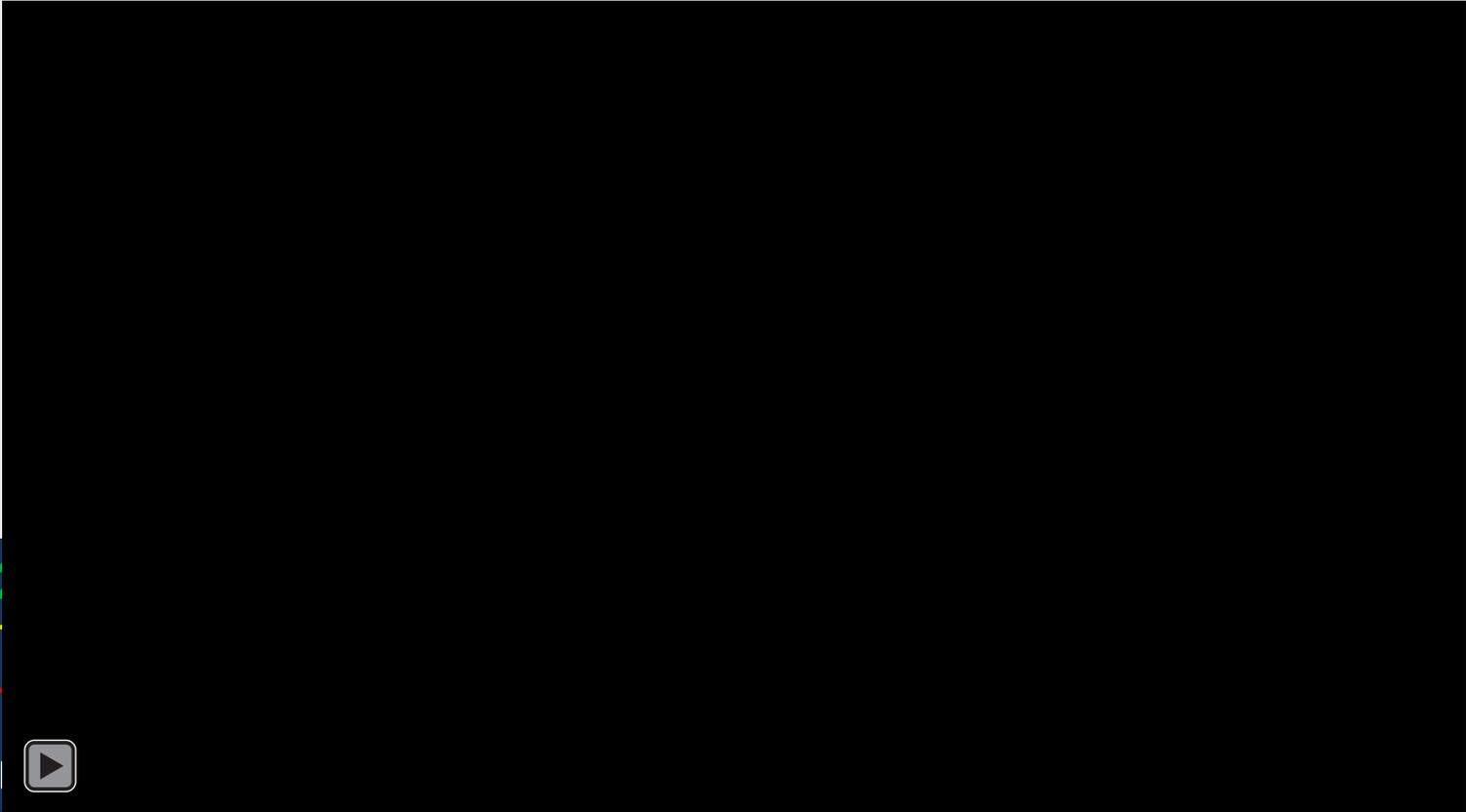
Excel Data

	A	B	C	D	E	F	G	H	I	J	L	M	N	O	P	AG	Y	Z
1	Series	Filename	White_1_2023-04-13_08_53_40.csv															
2	Direct	Record Description	Default_Route															
3	Side	Hardware ID	Laserlux G7															
4	Length	Firmware Version	1.412_2022-11-29 06:39:30 -0800_1113_2021 L21107															
5	Driven	Units	English															
6	Refer	Timezone Offset	-8															
7	Comm	Cal Factor	0.07986															
8		Cal Standard Value	325															
9		Cal IR Standard Value	1															
10	User n	Calibration Date and Time	2023-04-13_08:43:28															
11	Comm	Stripe Color type	White															
12	RL Cho	Minimum Good Value	250															
13	Maxim	Minimum Marginal Value-2	175															
14	Minim	Minimum Marginal Value-1	175															
15		Minimum Marginal Value-0	175															
16	Stand	Minimum Valid Value	50															
17	Averag	User Name																
18	Driven	RL Choice	RL Left															
19		Maximum	219.9															VDOP
20		Minimum	141.3															1
21		Standard Dev.	14.1															1.1
22		Average	175.14															1.2
23																		1.2
24																		1
25	27	Record #	Odometer	Date	Time	Latitude	Longitude	GPS Accur	Vehicle Sp	Temper	Humidity	Retro_Left_Maximum	Retro_Left_Minimum	Retro_Left_Average	Retro_Left_StdDev	Retro_Left_Stripe	Two_Stripe_A	
26	28	0	0	4/13/2023	8:53:40	30.63012	-96.43977	0.88	69	84.14	29.00%							1.1
27	29	1	0.05	4/13/2023	8:53:43	30.62965	-96.43911	0.84	69	84.1	28.90%	161.2	64.5	119	17.8	3		1.1
28	30	2	0.099	4/13/2023	8:53:46	30.62915	-96.43855	0.83	69	84.07	29.10%	141.5	79.9	111.7	10.7	3		1
29	31	3	0.149	4/13/2023	8:53:48	30.62863	-96.43799	0.81	70	84.02	29.40%	156.8	86.6	126.1	12	3.2		1
30	32	4	0.199	4/13/2023	8:53:51	30.62812	-96.43739	0.8	69	84.04	29.60%	171.1	72.3	115.9	12.6	3		1
31	33	5	0.249	4/13/2023	8:53:53	30.6276	-96.43677	0.79	69	83.93	29.80%	199.2	88	130.4	14.6	3.4		
32	34	6	0.298	4/13/2023	8:53:56	30.62708	-96.43611	0.78	69	83.93	30.00%	183.8	105.9	141.7	14.8	3.3		
33	35	7	0.348	4/13/2023	8:53:58	30.62666	-96.4356	0.78	70	83.86	29.90%	168.3	108	130.8	9.6	3.5		
34	36	8	0.398	4/13/2023	8:54:01	30.62609	-96.435	0.77	69	83.76	30.00%	207.3	70.9	141.2	17.8	3.5		
35	37	9	0.447	4/13/2023	8:54:04	30.62558	-96.4344	0.75	69	83.78	30.20%	219.9	77.1	148.3	18.8	3.5		
36	38	10	0.482	4/13/2023	8:54:05	30.62521	-96.4339	0.75	69	83.7	30.20%	142.3	99.7	107.8	12.3	3.3		





- Map Data



Green > 20
Yellow 10-20
Red < 10
White =



Pavement Marking Testing and Inspection



- Video Data

R_L	209	Max	457
		Min	113
		Std	65

Width	4.14 "
DC	2.36

RRPM's	0
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Name	121923 OSR EB We
Direction	
Side	
Ref.	
Date	12/19/2023
Driver	Mobile Retro
Length	1 M
Avg. Length	528.00000080256 ft

Time	02:48:16 PM
Driven	0.000 M



- TxDOT Approval of Retroreflectivity Measurements
 - TxDOT reviews data to make sure minimum performance levels are met
 - TxDOT clears deficiency in SiteManager
- Spreadsheet data vs maps vs video
 - Data manipulation (excel data vs map or video)
- <https://visibility.tti.tamu.edu/programs-and-guidance/mobile-pavement-marking-retroreflectivity-guidance/>

Mobile Pavement Marking Retroreflectivity Guidance



Full Presentation 📄 (110-130 minutes)

You may download the full guidance presentation, or you may access its individual parts below. The listed times are an estimate of the time required to go through the presentation.



- TTI Verification Program to assist with monitoring contractor collected retroreflectivity data
 - TTI will evaluate about 10% of jobs annually and compare TTI collected retroreflectivity data to the contractor collected data
 - TTI verification data to be collected within 7 days of contractor data
 - TTI schedules readings to get a representative distribution around the state and among contractors
- The contractors will not know which projects TTI has selected for verification testing
- Districts can contact TTI to check specific jobs or if they have any issues/questions
- Verification and spot monitoring should also be conducted by districts contracting the work to ensure accurate data is consistently collected



- TTI will be checking two things
 1. Does the contractor data fall within $\pm 20\%$ of the TTI data
 2. Does the contractor and/or TTI data meet the Item 666 retroreflectivity requirements
- Item 1 is for the verification program, TTI will take action on failing data to help the contractor improve future data collection (potentially revoke certification)
- Item 2 is additional comparison provided to TxDOT to make sure the markings are meeting specifications, TxDOT would need to take action on failing data



Pavement Marking Testing and Inspection



- Monthly report to MTD with verification testing results
- Soon, verification data from individual projects will be sent directly to Districts

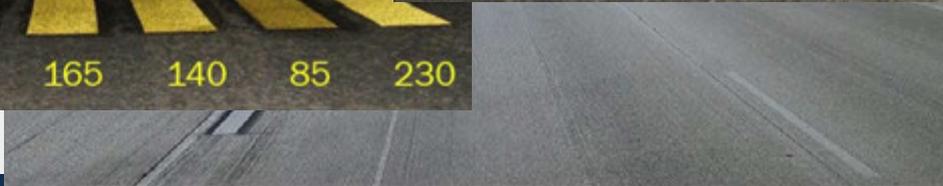
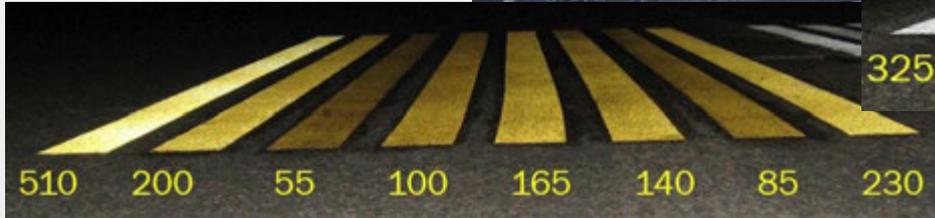
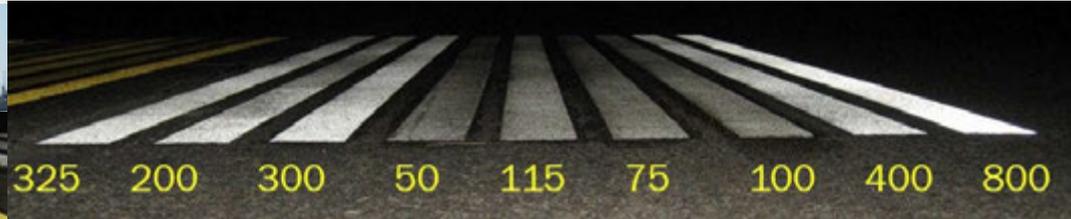
Roadway	TTI Retroreflectivity Averages (mcd/m ² /lux)						Provider Retroreflectivity Averages (mcd/m ² /lux)					
	White 1	White 2	Yellow 1	Yellow 2	Skip 1	Skip 2	White 1	White 2	Yellow 1	Yellow 2	Skip 1	Skip 2
FM 518	-	-	237	239	398	367	-	-	178	173	321	320
SH 6 (116)	-	-	-	-	286	279	-	-	-	-	281	266
SH 6 (117)	283	201	146	111	269	250	255	227	150	124	265	249
SH 35	552	511	275	259	565	537	419	400	255	240	386	371



Maintenance of Markings is Important



- Replace markings before they degrade beyond an adequate level of visibility.
- Unmaintained markings may lose daytime presence and contrast with the pavement.
- Unmaintained markings may have low retroreflectivity and low visibility at night.
- Poorly maintained markings can result in increased run-off-the-road crashes and are a common complaint of drivers.



How Does TxDOT Maintain Pavement Markings?

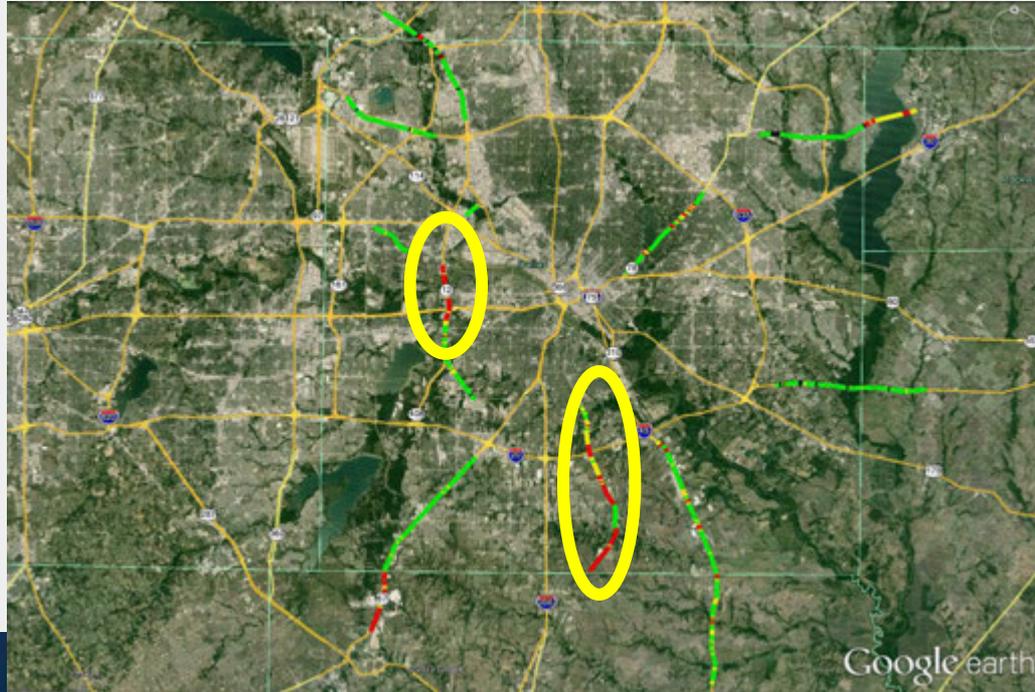


- Current practices vary by District
 - Day and Night Driving Inspections TxMAP/TxTAP
 - Marking/RPMs are a portion of what is assessed
- Tex-828-B Determining Functional Characteristics of Pavement Markings
 - Has both day and night tests
 - Utilizes subjective visual evaluations
- Performance Based pavement marking maintenance contracts
 - TxDOT research project 0-6705 evaluated effectiveness
 - There are maintenance and management benefits, but costs are higher than typical marking contracts
 - Performance of the contractors still needs to be monitored

How Does TxDOT Maintain Pavement Markings?



- Some districts let mobile pavement marking retroreflectivity contracts to evaluate a large portion of their markings to help prioritize striping based on retroreflectivity performance



How Does TxDOT Maintain Pavement Markings?



- Districts are beginning (encouraged) to develop striping plans (4-year)
- Used to monitor when markings are applied and estimate when they should be replaced
 - Requires logging marking installation information
 - Requires expected marking service life for varying conditions (road surface, ADT, etc.)

PAVEMENT TYPE	ASPHALT			CONCRETE			SURFACE TREATMENT (SEAL COATS)		
AADT	<1,000	1,000-10,000	>10,000	1,000-10,000	10,000-50,000	>50,000	<1,000	1,000-10,000	>10,000
EXPECTED LIFE	UP TO 4 YEARS	UP TO 4 YEARS	UP TO 3 YEARS	UP TO 4 YEARS	UP TO 4 YEARS	UP TO 4 YEARS	UP TO 4 YEARS	UP TO 4 YEARS	UP TO 3 YEARS
NEW MARKING TYPE	THERMO 90 MIL	PREFORMED TAPE	THERMO 100 MIL	THERMO 100 MIL	THERMO 100 MIL				
RESTRIPE MARKING TYPE	THERMO 90 MIL	REMOVE & REPLACE	THERMO 60 MIL	THERMO 60 MIL	THERMO 60 MIL				
ELP CYCLE (IDEAL)	5 YEARS	4 YEARS	3 YEARS	4 YEARS	3 YEARS	2 YEARS	5 YEARS	4 YEARS	3 YEARS

FHWA Maintaining Minimum Retroreflectivity Requirements



- FHWA has new **Minimum Maintained Retroreflectivity Levels** that are part of the 11th edition of the MUTCD

Table 1B-1. Target Compliance Dates Established by the FHWA

MUTCD Section(s)	Subject Area	Specific Provision	Compliance Date
2B.64	Weight Limit Signs	Paragraph 14 - requirement for additional Weight Limit sign with the advisory distance or directional legend in advance of applicable section of highway or structure	5 years from the effective date of this edition of the MUTCD
2C.25	Low Clearance Signs (W12-2)	Paragraph 1 - Required posting of the Low Clearance Advance (W12-2) sign in advance of the structure	5 years from the effective date of this edition of the MUTCD
2C.25	Low Clearance Signs (W12-2a, W12-2b)	Paragraph 8 - Recommended posting of Low Clearance Overhead (W12-2a or 12-2b) signs on an arch or other structure under which the clearance varies greatly	5 years from the effective date of this edition of the MUTCD
3A.05	Maintaining Minimum Retroreflectivity	Implementation and continued use of a method that is designed to maintain retroreflectivity of longitudinal pavement markings (see Paragraph 1 of Section 3A.05)	September 6, 2026



Section 3A.05 Maintaining Minimum Pavement Marking Retroreflectivity

Standard:

- 01 Except as provided in Paragraph 5 of this Section, a method designed to maintain retroreflectivity at or above 50 mcd/m²/lx under dry conditions shall be used for longitudinal markings on roadways with speed limits of 35 mph or greater.

Guidance:

- 02 Except as provided in Paragraph 5 of this Section, a method designed to maintain retroreflectivity at or above 100 mcd/m²/lx under dry conditions should be used for longitudinal markings on roadways with speed limits of 70 mph or greater.
- 03 The method used to maintain retroreflectivity should be one or more of those described in "Methods for Maintaining Pavement Marking Retroreflectivity" (FHWA-SA-22-028), 2022 Edition, FHWA or developed from an engineering study based on the values in Paragraphs 1 and 2 of this Section.

Support:

- 04 Retroreflectivity levels for pavement markings are measured with an entrance angle of 88.76 degrees and an observation angle of 1.05 degrees. This geometry is also referred to as 30-meter geometry. The units of pavement marking retroreflectivity are reported in mcd/m²/lx, which means millicandelas per square meter per lux.

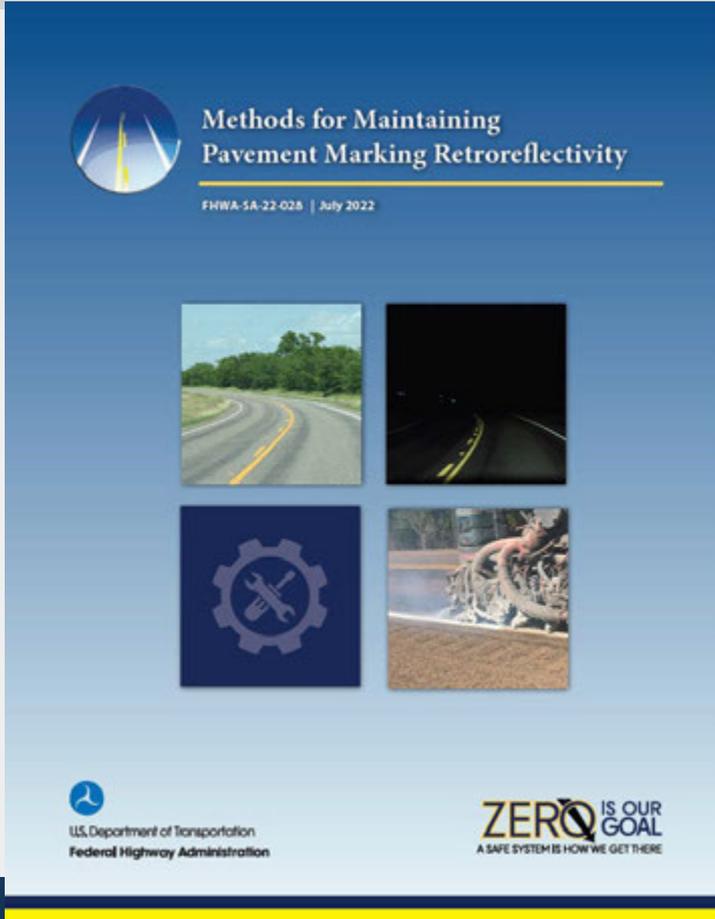
Option:

- 05 The following markings may be excluded from the provisions established in Paragraphs 1 and 2 of this Section:
- A. Markings where ambient illumination assures that the markings are adequately visible;
 - B. Markings on streets or highways that have an ADT of less than 6,000 vehicles per day;
 - C. Dotted extension lines that extend a longitudinal line through an intersection, major driveway, or interchange area (see Section 3B.11);
 - D. Curb markings;
 - E. Parking space markings; and
 - F. Shared-use path markings.



Support:

- 06 The provisions of this Section do not apply to non-longitudinal pavement markings including, but not limited to, the following:
 - A. Transverse markings;
 - B. Word, symbol, and arrow markings;
 - C. Crosswalk markings; and
 - D. Chevron, diagonal, and crosshatch markings.
- 07 Special circumstances will periodically cause pavement marking retroreflectivity to be below the minimum levels. These circumstances include, but are not limited to, the following:
 - A. Isolated locations of abnormal degradation;
 - B. Periods preceding imminent resurfacing or reconstruction;
 - C. Unanticipated events such as equipment breakdowns, material shortages, and contracting problems; and
 - D. Loss of retroreflectivity resulting from snow maintenance operations.
- 08 When such circumstances occur, compliance with Paragraphs 1 and 2 of this Section is still considered to be achieved if a reasonable course of action is taken to resume maintenance of minimum retroreflectivity in a timely manner according to the maintaining agency's method(s), policies, and procedures.



- FHWA report on methods to maintain marking retroreflectivity
- Provides suggested methods to maintain marking retro above required levels.
- Suggested methods include
 - Retroreflectivity Measurements
 - Visual Inspections (2 options)
 - Service Life Estimations (2 options)
 - Combinations of Methods

How is TxDOT Addressing FHWA Requirement?

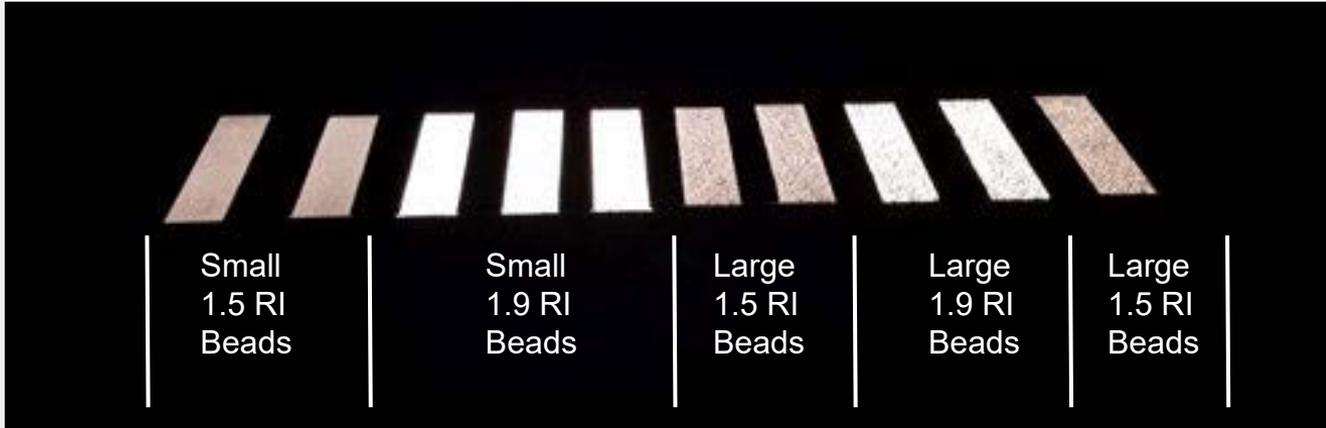


- TxDOT is working to address the FHWA Requirement and to Develop improved delineation across all conditions that exceed the requirements
- Research
 - Reviewing NTPEP data to include in DMS revisions
 - RTI research program
 - Current RFP 25-036: Predicting Field Performance of Pavement Markings Statewide in Texas
 - Current research project: 0-7122 – Evaluate Alternative Methods to Examine Visibility of Pavement Markings
 - MTD pavement marking test decks to be used for material qualification
 - Continued MTD testing of materials to ensure good materials are used
 - Pavement Marking Handbook rewrite

How is TxDOT Addressing FHWA Requirement?



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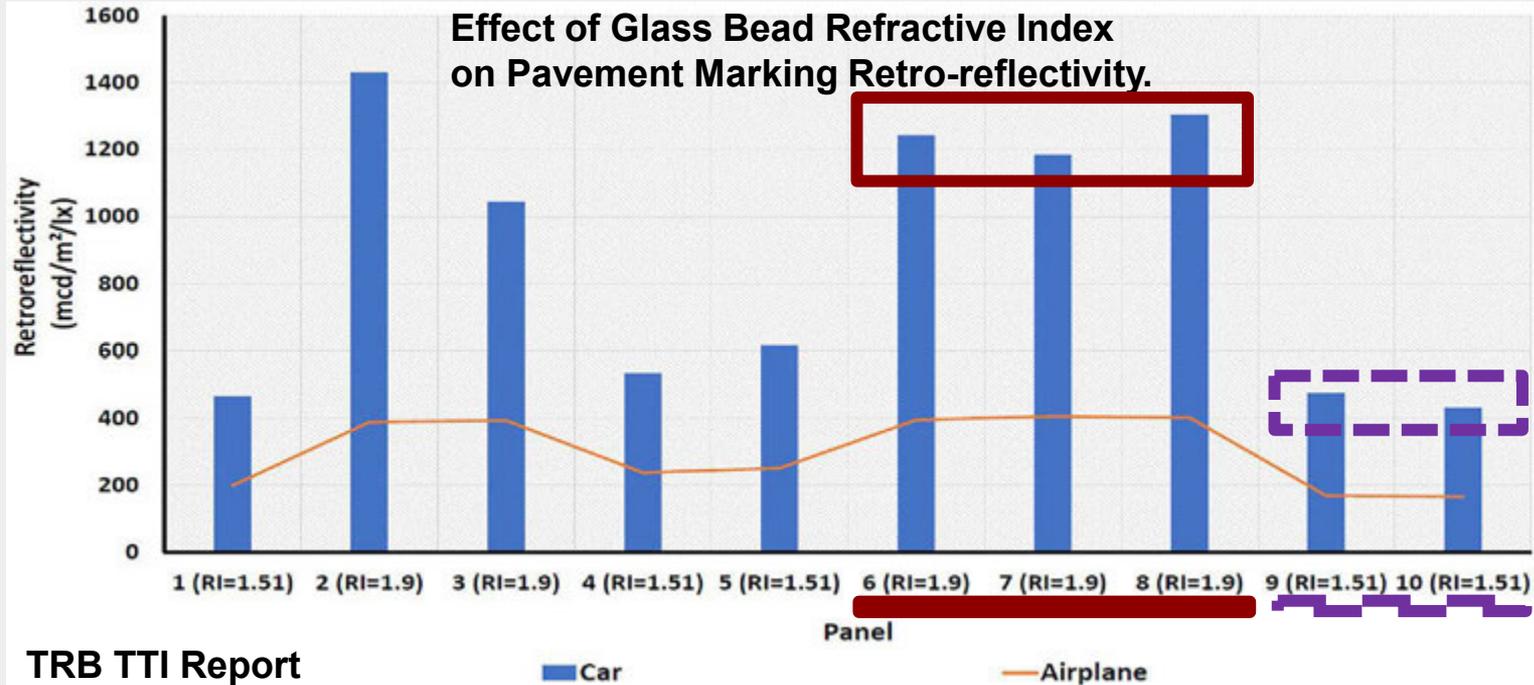


How is TxDOT Addressing FHWA Requirement?



Material Selection

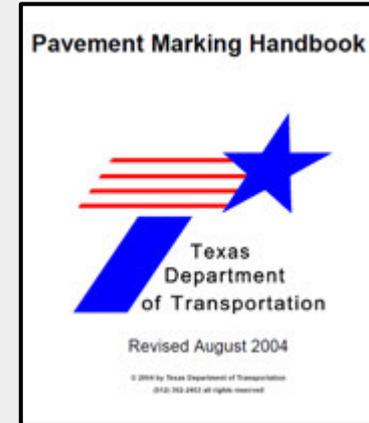
Using high index beads can improve initial retroreflectivity



How is TxDOT Addressing FHWA Requirement?



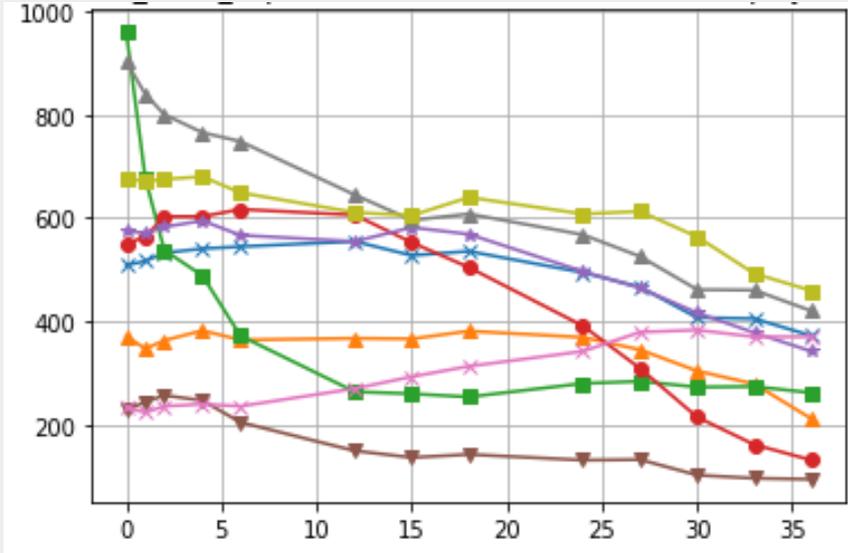
- Pavement Marking Handbook – Published in 2004, update expected in late 2024
- Updates to include
 - Revised details on material types
 - More details on retroreflectivity measurement
 - Marking material selection charts
 - Will provide future updates as additional TxDOT research is completed
 - New marking material expected service life based on TxDOT pavement marking test decks
 - TxDOT Policy on Maintaining Marking Retro to meet FHWA Requirements



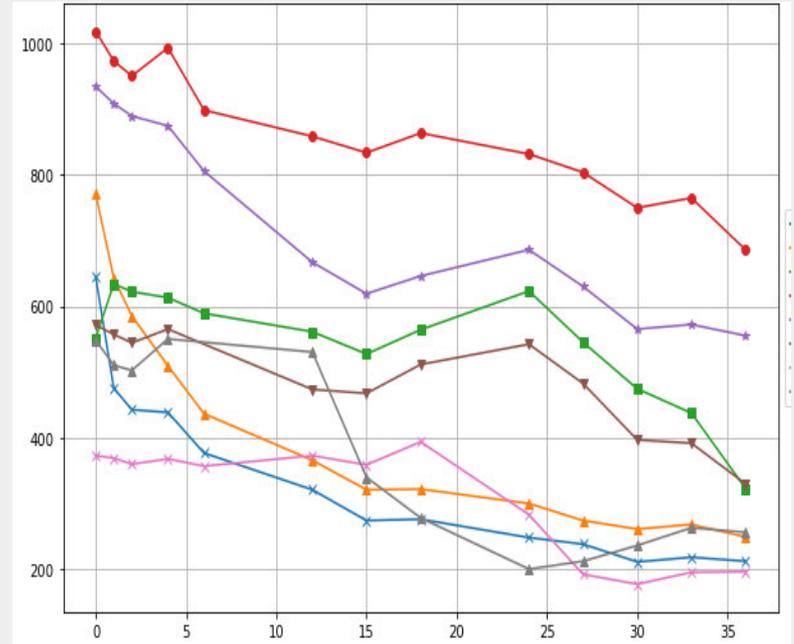


- **Pavement marking material type** – Paint, Thermoplastic, Multipolymer, Preformed Tape
- **Bead selection** – bead gradation, bead quality, bead application rate
- **Installation quality** – poor pavement surface preparation, poor application (too thin, applied too fast, bad materials, poor bead distribution, etc.), bad bead embedment
- **Pavement conditions** – seal coat more difficult to stripe than smoother surfaces
- **Weather (snowplowing)**
- **High traffic locations**

Different Material Types

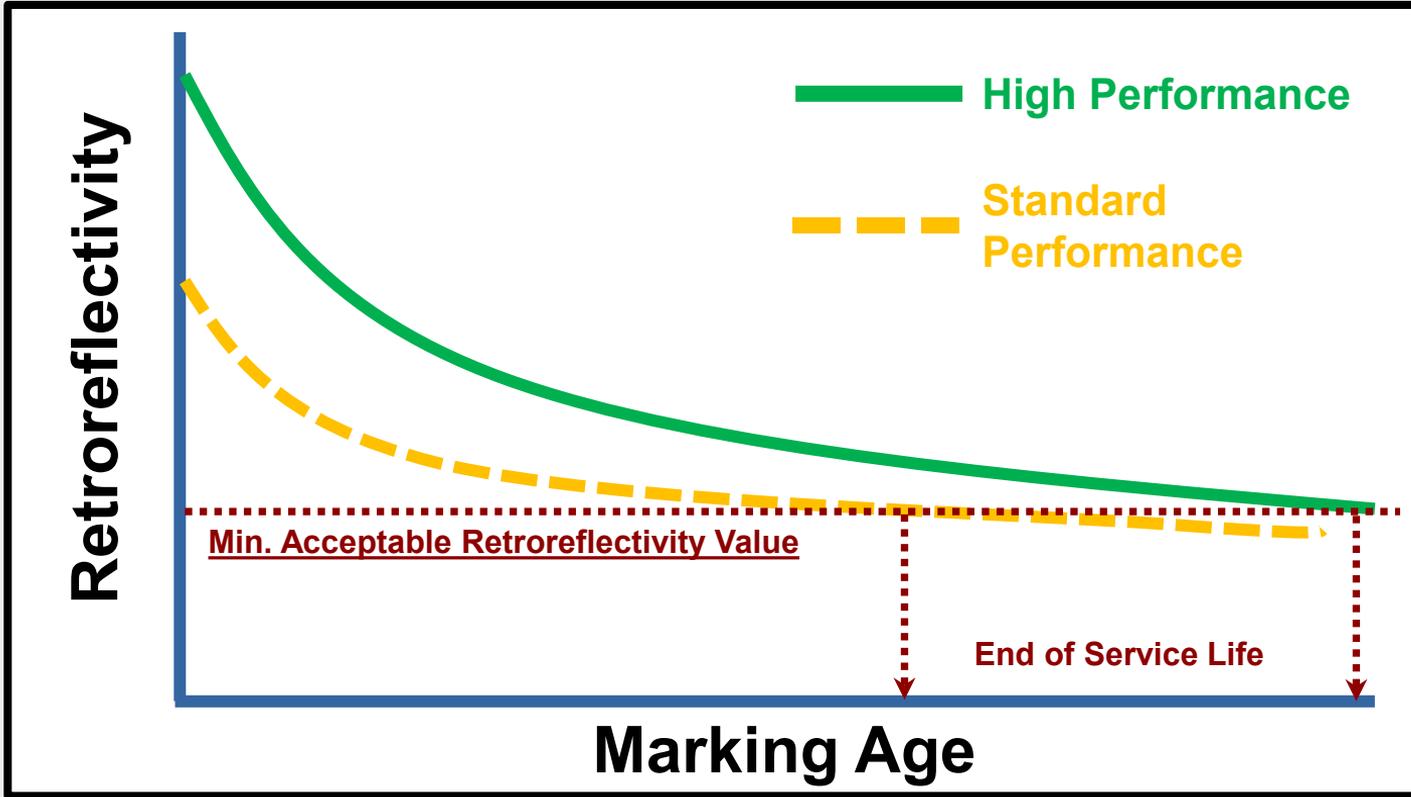


Multi-polymer



Thermoplastic

Different Material Types



Thin Marking Application



Poor Bead Embedment



Poor Bead Embedment



Poor Bead Embedment



Poor Bead Distribution



Asphalt vs Seal Coat



Poor Surface Preparation



Thermoplastic

**Both examples < 1
year old stripe on PCC**

Epoxy



Seal Coat Asphalt Tracking



Snowplowing



Wet-Night Conditions



Pavement Marker Performance





- Pavement markings and markers are important for safety and operations
- TxDOT is updating standards and specifications
- TxDOT is conducting research to improve pavement markings and markers
- TxDOT is developing a method(s) to address FHWA requirements to implement a method to maintain pavement marking retroreflectivity above required levels
- Initial inspection, and inspection over the service life of the markings is important to ensure good markings are maintained

QUESTIONS?

