Pavement Marking Retroreflectivity Workshops

Summary Report

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

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Kimley-Horn and Associates, Inc.

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16. Abstract
The FHWA is preparing to develop proposed language for the Manual on Uniform Traffic Control Devices (MUTCD) regarding pavement marking retroreflectivity. The purpose of this report is to summarize the recommendations from the two pavement marking retroreflectivity workshops that the FHWA held in the summer of 2007 regarding the upcoming proposed rulemaking on pavement marking retroreflectivity. This rulemaking effort is a result of the 1993 U.S. DOT Appropriations Act requiring the Secretary of Transportation to "…include a standard for minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings for all roads open to public travel." In response to this legislative mandate and after many years of research and proposed rulemaking, the FHWA has developed and adopted a set of minimum retroreflectivity levels for traffic signs, which became effective in January 2008.

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SI* (MODERN METRIC) CONVERSION

FACTORS APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with

Section 4 of ASTM E380.

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Appendices:

Introduction

The FHWA conducted two workshops on pavement marking retroreflectivity in the summer of 2007. The primary function of the workshops was to solicit input for the FHWA on future standards for the Manual on Uniform Traffic Control Devices (MUTCD) pertaining to pavement marking retroreflectivity (*1*). The first workshop was held on July 26th and 27th in Denver, Colorado. The second workshop was held on August 8th and 9th in Pittsburgh, Pennsylvania following the Institute of Transportation Engineers (ITE) International Meeting.

Denver Workshop


Pittsburgh Workshop

The purpose of the workshops was to solicit city, county, and State transportation agency input regarding minimum pavement marking retroreflectivity levels. These workshops provided three major benefits to the FHWA and the participants:

- The FHWA was able to identify the participants' concerns, impacts, and limiting factors associated with the implementation of minimum pavement marking retroreflectivity levels. This information will be helpful as the FHWA develops a proposed rule and technical assistance.
- The participating agencies contributed to the process of developing recommended structure and content for minimum pavement marking retroreflectivity levels.
- The participants learned from other agencies represented and became familiar with the most recent FHWA-sponsored research aimed at developing recommended minimum retroreflectivity levels.

Chapter 1
Workshop Participants and the FHWA Team

Participants who are involved in pavement marking issues were invited to attend the workshops and were selected in a manner designed to maximize geographical coverage and to ensure that State and local jurisdictions were represented in each workshop. The retroreflectivity team identified potential State government participants and worked with the President of the National Local Technical Assistance Program (LTAP) Association to identify potential county and city participants. There were approximately 15 participants in each workshop. The lists of participants at each workshop are shown in Appendix A. The breakdown of workshop attendee affiliations is shown in Table 1 below.

Table 1: Pavement Marking Retroreflectivity Workshop Attendee Affiliations

Location	State	County	City	Attorney	Professional Association	Industry	Total
Denver	7	2	2	1	1	1	14
Pittsburgh	9	3	1	1	0	1	15
TOTAL	16	5	3	2	1	2	29

The retroreflectivity team was made up of the following individuals:

- Greg Schertz – FHWA, Federal Lands Highway Division, FHWA Retroreflectivity Team Leader
- Matt Lupes – FHWA Office of Safety, Retroreflectivity Contact
- Paul Carlson – Texas Transportation Institute, Retroreflectivity Researcher
- Gene Hawkins – Texas A&M University and Texas Transportation Institute, professor and retroreflectivity researcher. Gene served as the facilitator for the Denver workshop.
- Kathy Falk – Kimley-Horn and Associates, MUTCD consultant. Kathy served as the note taker for the Denver workshop and the facilitator for the Pittsburgh workshop.
- Bruce Friedman – Kimley-Horn and Associates, MUTCD consultant. Bruce served as the note taker for the Pittsburgh workshop.

The same agenda (see Appendix B) was used for each workshop; however, the retroreflectivity team decided to use two different facilitators in order to foster different, independent ideas from each workshop.

Chapter 2
Summary of Workshop Discussions

The workshops were essentially divided into three main parts. During the first part of the workshop, the participants introduced themselves and the background material was presented, including the latest research findings (*2*,*3*). In the second part of the meeting, the workshop participants identified and discussed key factors pertinent to potential minimum pavement marking retroreflectivity language for the MUTCD. The third part of the workshop was devoted to soliciting input from the participants regarding the FHWA effort to develop a proposed rule on minimum pavement marking retroreflectivity levels. This input was the main reason for conducting the workshops and it will provide great value to the FHWA in future rulemaking efforts.

MAJOR DISCUSSION TOPICS

The main discussion topics from the participants are listed below by subheadings and in no particular order.

Maintenance Methods

- It does not seem possible to have a "one-size-fits-all" policy for the nation.
- What are the processes that can be used to identify when pavement markings fall below certain retroreflectivity levels?
- What type of equipment is available to measure retroreflectivity of pavement markings?
- In one workshop, the following methods were identified as being reasonable in terms of managing pavement marking retroreflectivity (the other workshop did not attempt to develop such a list):
    - Measurement
    - Nighttime inspections
    - Programmed replacement or expected life (based on service life)
    - Representative section
- The expected life of pavement markings is difficult to project because of the variety of factors that impact pavement markings when they are installed. More research is needed to determine the factors that impact pavement marking durability so that more reliable life cycle figures can be developed to allow agencies to establish robust pavement marking management programs.
- Methods to manage pavement marking retroreflectivity need to be fully identified and developed and tied to minimum retroreflectivity levels.
- Having the flexibility in the MUTCD to develop and implement agency-by-agency customized pavement marking management programs is an essential requirement to offset the expected burdens of the rulemaking.

Seasonal/Regional Constraints

- How can the MUTCD language accommodate agencies that receive regular snowfall and therefore have winter snow removal activities that can destroy pavement markings until the spring time when the markings can be refurbished?
- Seasonal pavement marking application periods in many regions of the country (those with snow).

Minimum Pavement Marking Retroreflectivity Factors

- Many participants would like to see lower numbers when raised retroreflective pavement markers (RRPMs) and/or lighting are present.
    - How should RRPMs be incorporated in the MUTCD language? Can the retroreflectivity of RRPMs be measured? If RRPMs are used in the MUTCD minimum pavement marking retroreflectivity language, should they also have minimum retroreflectivity requirements?
    - What if a roadway is lighted? Should the lighting level of the roadway be measured if lighting is used as a factor in the MUTCD minimum pavement marking retroreflectivity language? Continuous lighting can be defined a number of ways.
- Should white and yellow pavement markings have different retroreflectivity levels? Some participants thought that the yellow line was more important than the white line, but many others felt that in order to keep the requirement simple, the color of the marking should not be used to specify different levels.
- Credit (lower minimum retroreflectivity pavement marking values) should be provided for snow belt agencies that use continuous roadside delineation to supplement their markings.
- Should wider lines be given a credit?
- Can ceramic buttons or other raised markers be used in lieu of pavement markings? (MUTCD Section 3B.14)
- Transverse markings (crosswalks, symbols, word messages, stop lines, yield bars, lane reduction arrows, railroad symbols, etc.) are completely different from longitudinal markings. Many of the participants felt that transverse markings should be excluded from the requirements.
- Should speed or functional classification of the roadway be used to distinguish between different levels of retroreflectivity if a constant preview time is going to be the goal?
- Should the pavement type be addressed in the MUTCD?
- Average daily traffic (ADT), lane width, and horizontal alignment can impact the service life of markings.
- If different minimum levels are used in the MUTCD or in a supplemental document, then there should be a large enough difference between the values such that it makes sense to have two values. One participant thought the difference should be at least 50 millicandelas per square meter per lux ($mcd/m^2/lx$).
- If retroreflectivity is so important, should the requirement also include a contrast requirement?

- FHWA should consider the information a driver really needs from a marking. Is a curb in an urban area enough guidance for a driver in that environment? Why must markings be maintained on lower speed urban streets with curbs and often with lighting?

Economic Impacts

- The following question was raised in various forms at both workshops: What will the economic impact be? (The FHWA is completing a study of the economic impacts of the expected rulemaking effort.)
- How will local agencies that currently only restripe every 3 years be able to meet the minimum retroreflectivity levels?
- There will be a significant budget/financial concern for local agencies.
- If the FHWA goes forward with rulemaking, then a phase-in time is needed so that agencies can begin to build a case for the needed increase in budget, equipment, and personnel. Many local agencies will have to fight for the money and it will take time to convince board members and elected officials of the need for an increased budget.

Retroreflectivity Measurements

- How should pavement marking retroreflectivity be measured? Every inch of a long line can have a different retroreflectivity value. Is there a standard sampling technique that can be used when assessing the retroreflectivity for purposes of comparing to a minimum threshold? How long of a line should be measured? What if it is near an intersection with heavy turning movements, or near a gravel pit, or along a horizontal curve (or other areas where pavement marking retroreflectivity generally wears out in a localized fashion before the rest of the same line)?
- How and where would an agency measure retroreflectivity to determine if it is in compliance with MUTCD requirements?
- If values are generated, then they should be average values over a certain length of line or classification of roadway, but not each individual measurement.
- Can rumble stripes and other profiled markings be measured accurately?
- Is there a reliable method to measure wet markings?
- Is a windshield survey adequate? Many participants thought that a large difference in $mcd/m^2/lx$ is needed before a driver, even a trained driver, can notice a difference. However, others felt that trained drivers could detect differences less than 50 mcd.
- The cost of equipment to measure retroreflectivity is high for local agencies.
- What is the correlation between hand-held measurements and mobile measurements?
- Having long periods without rain in some areas can cause dirt/dust build up that leads to a low retroreflectivity measurement. Should pavement markings be cleaned before measuring?
- Many participants felt that the minimum retroreflectivity levels should only apply to clean and dry markings, realizing that clean is subjective.

Safety Benefit

- Does the B/C ratio of minimum retroreflectivity justify the effort? Is there an associated crash reduction factor?
- Is there any evidence linking maintained retroreflectivity levels and safety? The NCHRP research project 17-28 was not designed to evaluate the safety relationship of retroreflectivity levels near the minimum values so it only provides indirect information – and the information it does provide says that the important thing is that markings are present and visible to drivers, but what is less important with respect to safety is whether the markings are: "new marking bright" or "old marking bright." The researchers think drivers adjust their driving to compensate for lower visibility conditions, but little research exists to support their hypothesis. The data they used (from CalTrans) had very little samples of pavement marking retroreflectivity less than 100 mcd/m^2/lx.

Tort Liability

- Will tort liability potential increase with minimum pavement marking retroreflectivity standards established in the MUTCD?
- Setting a threshold in the MUTCD will increase liability for agencies needing to maintain the markings to that standard.
- Having a maintenance management system in place and documented will be key to avoid tort liability.
- Some participants expressed preference not to have the values in the MUTCD.

MUTCD Language

- It does not seem reasonable to expect that agencies meet minimum retroreflectivity levels 24 hours a day, 7 days a week, 365 days a year. Many times snow and debris cover the roadway. Even rainy or just wet conditions can have a significant impact on retroreflectivity. How will FHWA address these issues?
- The standard should be simple with many options.
- It was felt that maintenance methods need to be included in the MUTCD and possibly should be included as a Standard statement without having the minimum retroreflectivity levels included in a Standard statement – although many participants questioned whether this approach would truly satisfy the Congressional directive since the minimum retroreflectivity levels would not be included as a standard.
- Can the MUTCD language look like the edge line and center line warrants so that they include "shall," "should," and "may" language (i.e., Standard, Guidance, and Option statements)?
- When markings fall below the minimum levels, they should be "programmed for replacement"?
- Since the sign rulemaking has excluded some signs, it is probably OK to exclude some pavement markings.
    - About half of the participants thought that the retroreflectivity requirements should only apply to markings that are required by the MUTCD. One of the thoughts supporting this position was that if requirements are included for all

markings, then agencies might choose not to provide markings that are not required by the MUTCD.
    - Do temporary markings in work zones have to meet minimum retroreflectivity levels?
- The MUTCD language should be flexible enough so that agencies can be considered to be in compliance as long as they have a pavement marking program in place so that if a marking is found to be deficient, it should be programmed for replacement in a reasonable time frame, but the agency would not be held liable as long as the program was in place, documented, and a schedule for refurbishing exists.
- If agencies conduct and document their own research, they should be allowed to set the requirements as per the research recommendations.
- Is there a way for the FHWA language to end up specifying certain types of materials based on ADT (similar to the exemptions that FHWA included in the minimum retroreflectivity rule for sign sheeting)? For instance, if you have an ADT > 4,000, then do not use waterborne paints.

Other Comments

- A supplemental document, like that being proposed along with the minimum sign retroreflectivity levels, is needed to address the plethora of issues pertinent to pavement marking retroreflectivity minimums that will not be evident in the typically condensed MUTCD language. Potential items for the supplemental document include:
    - Effect of climate on pavement marking retroreflectivity
    - Expected Pavement Marking Life Table
    - Color shift, particularly of yellow pavement markings
    - Assessment methods – take into consideration various methods for assessment and can even use multiple methods in different geographical areas of a jurisdiction or at different times of the year.
        - Nighttime visual inspections – at night in a sedan using individuals trained in marking inspection. Agencies shall adopt an inspection procedure that relates the inspection to the minimum values in Table 3A-1. The visual inspection evaluation point should be located 30 meters in front of the vehicle.
        - Retroreflectivity measurement – using American Society for Testing and Materials (ASTM) standard method (method under development) or a formal measurement procedure adopted by an agency.
        - Representative section – a specific portion of a roadway segment is identified as representative of that roadway. The retroreflectivity of the segment is monitored to determine retroreflectivity of the full roadway section.
        - Predictive model – an agency develops a model that considers material type, pavement surface, traffic volume, weather conditions, and other factors to predict the expected life of a marking.
    - Management methods
        - Agencies should maintain a record keeping process that identifies materials, application dates, contractor information, retroreflectivity test results, and other factors.
        - Programmed replacement interval.

    - Marking materials
        - Agencies should consider using marking material and/or applications (such as recessed markings) that are durable enough to last through a period of time when it is not feasible to replace markings whose retroreflectivity falls below the minimum values.
    - Potential for lower retroreflectivity values for rumble strips. Related situations are internally illuminated markers.
- A general increased focus on pavement markings is needed. Many participants believed that the Congressional directive will provide the catalyst and might even lead industry to develop brighter and longer lasting pavement marking materials.
- One of the possible outcomes of the rulemaking is that agencies might begin using more durable materials. However, others pointed out that in snow areas it has been shown that retroreflectivity is only a dream in the spring time. These participants felt that what might happen is that more and more agencies will move away from durable products to using more two-cycle waterborne paint applications – one installation as early as possible in the spring and then one more as late as possible in the fall.

FACTORS TO BE CONSIDERED

The first half of each workshop included many discussions related to the factors that should be addressed, or at least discussed, in terms of the FHWA's role in developing minimum pavement marking retroreflectivity levels for the MUTCD. The discussions up to this point were all group discussions. As the first day was closing, the facilitator from each workshop asked the participants to spend some time thinking about and developing a table of minimum retroreflectivity levels that might be appropriate for the MUTCD. The homework assignments were collected the morning of the second day of the workshop and summarized in order to develop a priority of topics to help facilitate the discussions. The following factors were included in the submitted assignments, shown in the order of their respective frequency of appearance:

21	Rulemaking requirement should be applicable for longitudinal lines only
17	Allow a discount for Retroreflective Raised Pavement Markers (RRPMs)
16	Retroreflectivity levels should be classified by roadway speed
11	Retroreflectivity levels should be classified by color of markings
9	Retroreflectivity levels should be classified by marking configuration (center line or center line with lane lines/edge lines)
6	Allow a discount for roadway lighting
2	The requirements should be coordinated with pavement marking warrants
2	Retroreflectivity levels should be classified by function classification
2	Retroreflectivity levels should be classified by ADT
1	Retroreflectivity levels should be classified by pavement type
1	Retroreflectivity levels should be classified by environment (urban versus rural)
1	Allow a discount for continuous roadside delineation
1	Allow a discount for rumble stripes

Chapter 3
Recommended MUTCD Language

This chapter describes the specific recommendations originating from the workshops for the FHWA to consider in developing the proposed rule for the Federal Register. These recommendations reflect the general opinions of the majority of the workshop participants as interpreted by the report authors. Given the range of opinions regarding minimum retroreflectivity levels for pavement markings, the participants worked together to develop recommendations for the FHWA to consider. Suggested MUTCD wording from each workshop is shown in Appendices C and D.

MUTCD Language

- A phase-in time is needed to allow agencies time to study/customize the most appropriate method to manage pavement marking retroreflectivity in their jurisdiction. This should include a time for the study of the method, and then additional time to gear up, which might require reprioritizing as well as presentations and reports to budget personnel (e.g., city council) for the funds needed to purchase equipment, survey current conditions, attain management services, etc.
- The MUTCD language should include a Standard statement requiring a method to maintain pavement marking retroreflectivity in accordance with a table to be published in the MUTCD. The requirements in this Standard statement should only apply to markings that are required by the MUTCD. The Standard statement should also require that pavement markings with retroreflectivity levels below the minimum shall be scheduled for replacement when conditions permit.
- An Option statement should be included that exempts symbols, arrows, and words, unless otherwise required by the MUTCD.
- An unambiguous measurement protocol is needed to compare marking retroreflectivity to the minimum levels developed by the FHWA.

Table of Minimum Retroreflectivity Levels

- Include classifications based on speed of the roadway.
- Provide a discount for RRPMs and lighting, but include unambiguous information concerning the working condition of RRPMs and lighting.
- Include classifications based on color of the marking.

Maintenance Methods

- List maintenance methods that the FHWA considers acceptable.
- Allow flexibility for agencies to customize their own method based on their specific needs in their jurisdiction.
- Provide a supplemental document that includes additional information.

Chapter 4
Summary

The FHWA is preparing to develop proposed language for the Manual on Uniform Traffic Control Devices regarding pavement marking retroreflectivity. The purpose of this report was to summarize the recommendations from the two pavement marking retroreflectivity workshops that the FHWA held in the summer of 2007 regarding the upcoming proposed rulemaking on pavement marking retroreflectivity. This rulemaking effort is a result of the 1993 U.S. DOT Appropriations Act requiring the Secretary of Transportation to "…include a standard for minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings for all roads open to public travel." In response to this legislative mandate and after many years of research and proposed rulemaking, the FHWA has developed and adopted a set of minimum retroreflectivity levels for traffic signs, which became effective in January 2008. The FHWA is now prepared to continue with pavement marking retroreflectivity rulemaking.

Through the course of these workshops, the participants' major discussion topics included:

- Maintenance methods
- Seasonal/regional constraints
- Minimum pavement marking retroreflectivity factors
- Economic impacts
- Retroreflectivity measurements
- Safety benefit
- Tort liability
- MUTCD language

The FHWA plans to use the information gathered from the workshops to continue forward with proposed pavement marking retroreflectivity rulemaking. The following activities are planned as part of that process:

- The FHWA develops proposed language for the MUTCD and issues a Notice of Proposed Amendments to the MUTCD in the Federal Register to solicit public comment on the proposed language.
- The public has a 6-month period during which to submit comments.
- The FHWA reviews the comments that are submitted and develops the Final Rule for the MUTCD.
- The FHWA publishes the Final Rule for pavement marking retroreflectivity in the MUTCD and in the Federal Register.

References

1. Manual on Uniform Traffic Control Devices for Streets and Highways. Federal Highway Administration, United States Department of Transportation, Washington, DC, 2003.
2. Debaillon, C., P.J. Carlson, Y. He, T. Schnell, and H.G. Hawkins. Review and Development of Recommended Minimum Pavement Marking Retroreflectivity Levels.
3. Deballion, C., P.J. Carlson, Y. He, and T. Schnell. Updates to Research on Recommended Minimum Levels for Pavement Marking Retroreflectivity to Meet Driver Night Visibility Needs, FHWA- HRT-07-059, FHWA, US DOT, Washington, DC, 2007.

Appendix A
Workshop Participants

Denver Workshop Participants

Name	Agency
Vagn Askjaer	Flint Trading
Nathan Beauheim	City of Cheyenne, WY
Shane Chevalier	Colorado DOT
Brian Field	Dodge County, WI
Steve Ford	Mendocino County, CA
Brad Henry	Kansas DOT
Jon Jackles	Minnesota DOT
Rick Knowles	City of West Des Moines, IA
Ron Kroop	Oregon DOT
Ed Lagergren	Washington DOT
San Lee	Colorado DOT
Charles Meyer	Colorado DOT / AASHTO
Harry Morrow	Colorado DOT
Dan Waddle	Nebraska DOT

Pittsburgh Workshop Participants

Name	Agency
Keith Browning	Douglas County, KS
Derrick Castle	Kentucky DOT
Eric Hedman	3M
Joe Hursen	Allegheny County, PA
Allen Lee	City of Lincoln, NE
Mark McConnell	Mississippi DOT
Meredith McDiarmid	North Carolina DOT
Jill Morena	Michigan DOT
Eric Pitts	Georgia DOT
Tobey Reynolds	New Hampshire DOT
Steve Smallhover	Allegheny County, PA
Jay Smith (via phone)	Missouri DOT
Ken Williams	Pennsylvania DOT
Roy Wright	Texas DOT

Appendix B
Workshop Agenda

GOAL: Develop input for the FHWA on future language for the Manual on Uniform Traffic Control Devices (MUTCD) pertaining to pavement marking retroreflectivity.

AGENDA:

DAY 1

1. **Welcome**
   - 1.1. Opening comments
   - 1.2. Review meeting objectives and schedule
   - 1.3. Self-introductions
2. **Congressional Language**
3. **MUTCD rulemaking process**
4. **Review MUTCD language for min sign retro (NPA & SNPA)**
5. **FHWA research recommendations**
6. **BREAK**
7. **Discussion of Key Issues**
   - 7.1. Identify critical pavement marking minimum retroreflectivity issues as determined by the participants
   - 7.2. Identify pavement marking minimum retroreflectivity stakeholders and expectations of stakeholders
   - 7.3. Suggestions of additional critical issues by the facilitator
   - 7.4. Identify basic strategies for MUTCD language
   - 7.5. List of issues that need to be identified during the discussion
   - 7.6. Related issues
8. **Develop basic outline for MUTCD language**

DAY 2

9. **Refine/finalize MUTCD language**
10. **Break**
11. **Develop recommendations for FHWA consideration**
12. **Meeting wrap-up (review recommended MUTCD language)**

Appendix C
Suggested MUTCD Wording from Denver Workshop Participants

Standard:
Public agencies or officials having jurisdiction shall use an assessment or management method to maintain pavement marking retroreflectivity at or above the minimum values established in Table 3A-1 for all pavement markings required by this Manual. The minimum retroreflectivity values in Table 3A-1 shall be applied to markings using the following:

- **Clean and dry markings**
- **An average of retroreflectivity values over a representative length of marking**

If the retroreflectivity of a pavement marking falls below the minimum values, markings shall be scheduled for replacement when conditions permit.

Option:
Agencies may exclude the following types of pavement markings from the retroreflectivity maintenance guidelines described in this section:

A. Markings that are not required by the MUTCD
B. Symbols, arrows, and words

Table 3A-1. Minimum Maintained Retroreflectivity Levels (mcd/m^2/lx)

	Without RRPMs			With
Marking Configuration	≤ 50 mph	55-65 mph	≥ 70 mph	RRPMs or Lighting
With Edge Lines or Lane Lines	40	60	90	40
Yellow Center Line Only	90	250	570	50

Add note that retroreflectivity values ($R_{L)}$ apply to all colors
Speed is the nighttime speed of the road
[There are questions about the values for roads that are curb and gutter or median divided.]

If RRPMs are used to reduce the minimum retroreflectivity level, there shall be at least three in view and in good working condition. [Need to revise "good working condition" to provide a quantitative measure of RRPM performance.]
If roadway lighting is used to reduce the minimum retroreflectivity level, the reduction shall be applied only to those markings that receive an adequate level of illumination from the roadway lighting. [Need to define "adequate."]

Compliance Dates
2 years to adopt a method
5 years for markings to comply with minimums and methods

Appendix D
Suggested MUTCD Wording from Pittsburgh Workshop Participants

Standard:

Agencies shall have an assessment or management program to maintain longitudinal pavement marking retroreflectivity at or above the minimum levels established in Table 3A-1.

Guidance:

The pavement marking management system should provide a system for planning the normal application of pavement markings systemwide, for monitoring the quality of the pavement markings, and a plan for correcting deficiencies that fall outside of the normal pavement marking cycle. The pavement marking management system should account for normal cycles of wear, tear, and deterioration in a way that allows agencies to identify areas that are approaching minimum levels and the agency should schedule pavement markings to be replaced in a reasonable and timely manner before non-compliance occurs.

If unforeseen circumstances occur that cause pavement markings to fall below the minimum levels, the agency should replace those pavement markings in a reasonable and timely manner.

One or more of the following assessment or management methods should be used to maintain pavement marking retroreflectivity at or above the minimum levels identified in Table 3A-1.

Three suggested options for Table 3A-1:

Option 1

Table 3A-1 Minimum Maintained Retroreflectivity Levels (mcd/m^2/lx)

	Without RRPMs		With RRPMs
	50 mph or less	≥ 55 mph	
White	80	100	X
Yellow	65	80	X

Option 2

Table 3A-1 Minimum Maintained Retroreflectivity Levels (mcd/m^2/lx)

	Without RRPMs			With RRPMs
	50 mph or less	55-65 mph	≥ 70 mph	
White	40	60	90	40
Yellow	90	250	570	50

Option 3

Table 3A-1 Minimum Maintained Retroreflectivity Levels (mcd/m^2/lx)

Other Streets		All streets with RRPMs, lighting, or delineation
Less than 50 mph	50 mph or more	
100	150	50

Four suggested options for assessment methods:

Option 1

1. Sample panel of stripe at minimum level. Place sample panel next to roadway stripe and compare. Procedure must be performed by a qualified inspector.

2. Expected Stripe Life: Develop stripe replacement schedules based on durability of varying stripe materials.

3. Sample X locations on a stripe project length. Average the retro readings for those samples. Pass or fail based on minimum requirement.

4. Use a mobile reflectometer to get retro readings. Pass or fail based on minimum requirement.

Note: Exceptions to these assessment methods are between the months of __ and __ (winter months) in northern states.

Option 2

One or more of the following assessment or management methods shall be used to maintain pavement marking retroreflectivity at or above the minimum levels identified in Table 3X-X.

A. Measured Pavement Marking Retroreflectivity: Pavement marking retro is measured using a reflectometer. Markings with retro below the minimum levels should be replaced.

B. Blanket Replacement: All pavement markings in an area/corridor, or of a given type, should be replaced at specified intervals. This eliminates the need to assess R_L or track the life of the individual markings. The replacement interval is based on the expected marking life, compared to the minimum levels, per Table 3X-X.

C. Expected Marking Life: When markings are applied, the application date is recorded so that the age of the marking is known. The age of the marking is compared to the expected marking life, as stated in Table 3X-X. Markings older than the expected life shall be replaced.

Expected Life Table:

Option 3

1. Measure retroreflectivity, handheld or mobile per ASTM, in April or May. Restripe locations within 90 days.

2. Trained inspector reviews x% of roadway. If y% are unacceptable, restripe within 90 days.

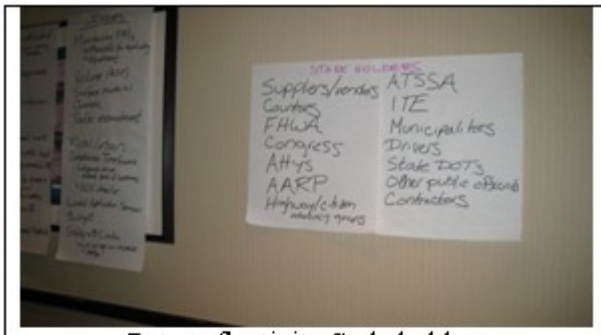
3. Restripe every X (days, years, months) based on model (previous experience or research, or data from ...). No review required.

Option 4

Each agency should have an assessment method in place for monitoring and then for the replacement. This should be set from the data gathered that indicates the typical life span of the marking for rural and urban roadways.

- Assessment method in place
- Replacement schedule for pavement markings that fall below minimum retroreflectivity levels (take into account seasons when you cannot restripe, etc.)

Appendix E
Additional Photos from Pittsburgh Workshop

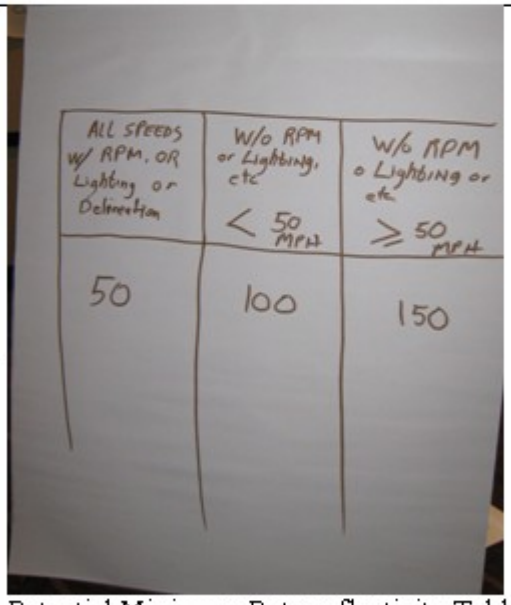


Retroreflectivity Stakeholders

Issues to be Considered

Potential Minimum Retroreflectivity Tables

Example Retroreflectivity Graphs by Month



Potential Minimum Retroreflectivity Table