

# **MINIMUM LEVELS OF IN-SERVICE RETROREFLECTIVITY FOR PAVEMENT MARKINGS: SUMMARY OF WORKSHOP FINDINGS**

Prepared by

Gene Hawkins  
Hawkins Engineering  
College Station, Texas

Greg Schertz  
Federal Highway Administration  
Denver, Colorado

Jim Carlson  
Minnesota Department of Transportation  
Minneapolis, Minnesota

and

Rick Beck  
Minnesota Department of Transportation  
Minneapolis, Minnesota

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## CHAPTER 1

# INTRODUCTION

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In the fall of 1999, the Federal Highway Administration (FHWA) sponsored a series of three workshops on minimum levels of in-service retroreflectivity for pavement markings. This report describes those workshops and the recommendations resulting from the workshops.

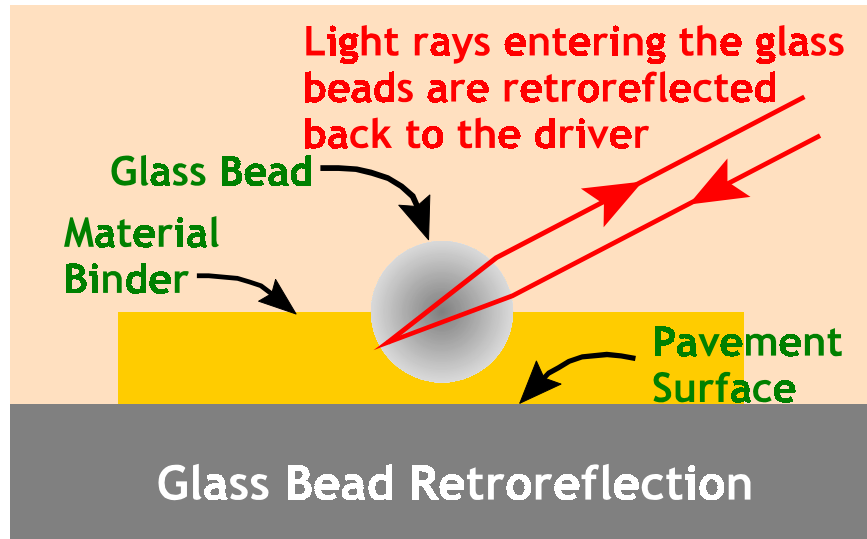
### BACKGROUND

Traffic control devices provide one of the primary means of communicating vital information to users of the street and highway transportation network in the United States. Pavement markings are one of the three basic types of traffic control devices, the others being signs and signals. Pavement markings serve several important purposes, including defining the travel path for vehicles and supplementing other traffic control devices. In some cases, pavement markings fulfill a role that cannot be filled by any other type of device. Markings also present an advantage in that they are located in front of the vehicles in the driver's cone of clearest vision.

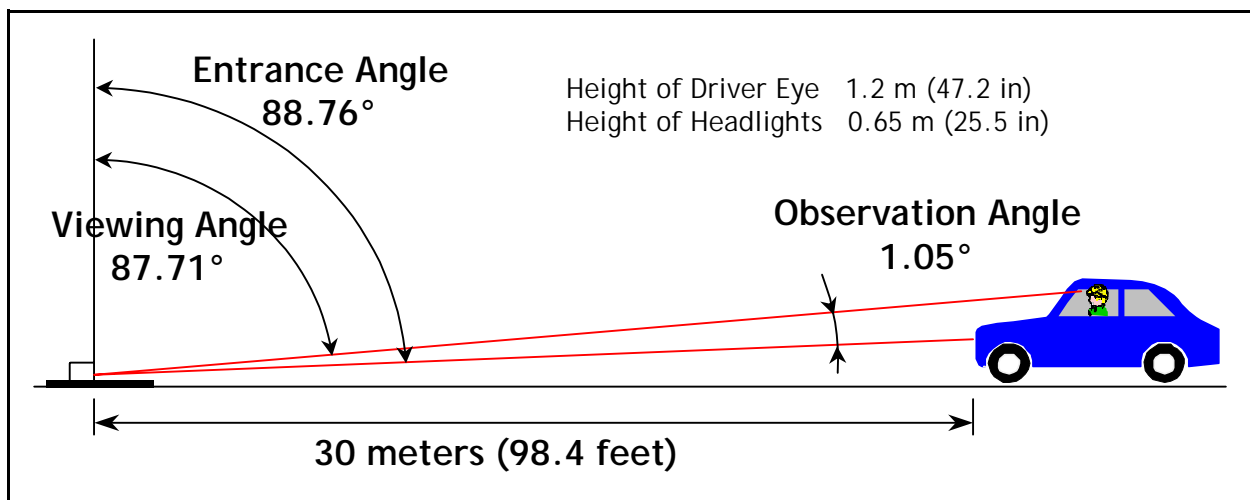
Markings can be longitudinal, transverse, or symbols, in either white or yellow. The *Manual on Uniform Traffic Control Devices*, or MUTCD (1) establishes the requirements for markings and other types of traffic control devices. One of these requirements is that markings "which must be visible at night shall be retroreflectorized unless ambient illumination assures adequate visibility" (1).

Retroreflectivity is the property that directs light back to the source from which it came. Retroreflectorization of pavement markings is accomplished through the use of glass or ceramic beads placed on and/or in the marking binder material. The bead returns illumination from a headlight back to a driver, as shown in Figure 1. Pavement marking retroreflectivity is represented by the coefficient of retroreflected luminance ( $R_L$ ) and the unit of measure is millicandela per meter squared per lux (mcd/m<sup>2</sup>/lux). Figure 2 illustrates the standard measurement geometry for pavement marking retroreflectivity.

Retroreflectorization of pavement markings was first described in the 1942 MUTCD, but it was not until the 1954 revision of the 1948 MUTCD that there was a requirement that pavement markings be retroreflectorized. In that revision, rural pavement markings were required to be retroreflectorized. The 1961 MUTCD was the first to require retroreflectorization of all pavement markings having application at night. This requirement has continued to exist in all succeeding editions of the MUTCD.



**Figure 1. Pavement Marking Retroreflectivity Principles**



**Figure 2. Standard Measurement Geometry for Pavement Marking Retroreflectivity**

Although there has been a requirement for retroreflectorized pavement markings in the MUTCD for almost forty years, this requirement has no specific values of retroreflectivity. In 1985, the Center for Auto Safety (CAS) petitioned the Federal Highway Administration (FHWA) to initiate rulemaking on the issue of minimum standards of retroreflectivity for traffic control devices. That petition contended that the range of drivers was not being accommodated by the traffic control devices allowed in the MUTCD with respect to nighttime conspicuity dependent upon retroreflective illumination. In April 1985, the FHWA published a request for comments and a notice of proposed amendment to the MUTCD in the *Federal Register*. The *Federal Register* notice summarized the problem and asked ten questions regarding retroreflectivity of signs and markings. The text of the notice is provided in Appendix A.

Several years later, Congress included the following requirement in the 1993 Department of Transportation Appropriations Act:

*“The Secretary of Transportation shall revise the MUTCD to include a standard for a minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings which apply to all roads open to public travel.”*

The FHWA research program on the nighttime visibility of traffic control devices preceded the CAS petition for minimum levels of retroreflectivity for signs and markings. This research program continued through the 1980s and into the 1990s. This research included several different research studies, which are described in a draft FHWA report that presents research recommendations for minimum levels of in-service retroreflectivity for pavement markings (2). These values are presented in Table 1.

**Table 1. FHWA Research Recommendations for Minimum Retroreflectivity Values**

Option 1		Non-Freeway, ≤ 40 mph	Non-Freeway, ≥ 45 mph	Freeway, ≥ 55 mph
Option 2		≤ 40 mph	≥ 45 mph	≥ 60 mph, > 10K ADT
Option 3		≤ 40 mph	45-55 mph	≥ 60 mph
With RRPMs	White	30	35	70
	Yellow	30	35	70
Without RRPMs	White	85	100	150
	Yellow	55	65	100

Source: Reference (2).

Note: Retroreflectivity values are mcd/m<sup>2</sup>/lux and measured at 30 meter geometry.

RRPMs – Retroreflective Raised Pavement Markers.

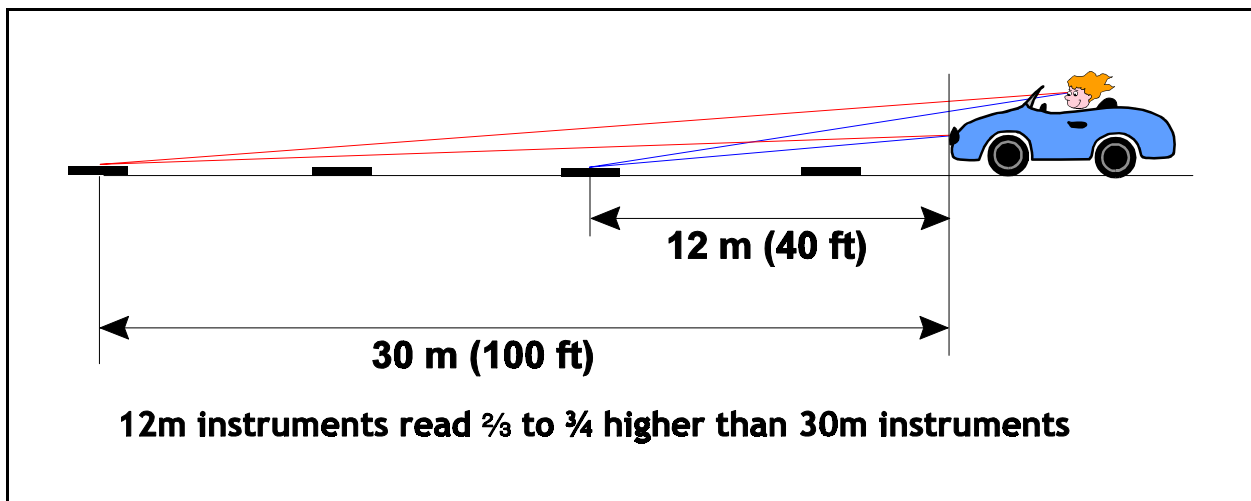
## RELATED ACTIVITIES

There are several current and/or recent activities related to pavement marking retroreflectivity that may have an impact on the development or implementation of minimum levels of pavement marking retroreflectivity. These include the HITEC evaluation of pavement marking retroreflectometers, the AASHTO Retroreflectivity Task Force, upcoming research to establish a national retroreflectivity calibration standard, and a final rule on criteria for centerline and edge line warrants.

### HITEC Evaluation of Pavement Marking Retroreflectometers

A critical issue associated with the retroreflectivity of pavement markings is the ability to measure retroreflectivity. Pavement marking are manufactured on-site and it is not practical to remove a pavement marking so that the retroreflectivity can be measured with a high level of accuracy. Instead, agencies and contractors rely upon portable retroreflectometers to measure the retroreflectivity of pavement markings.

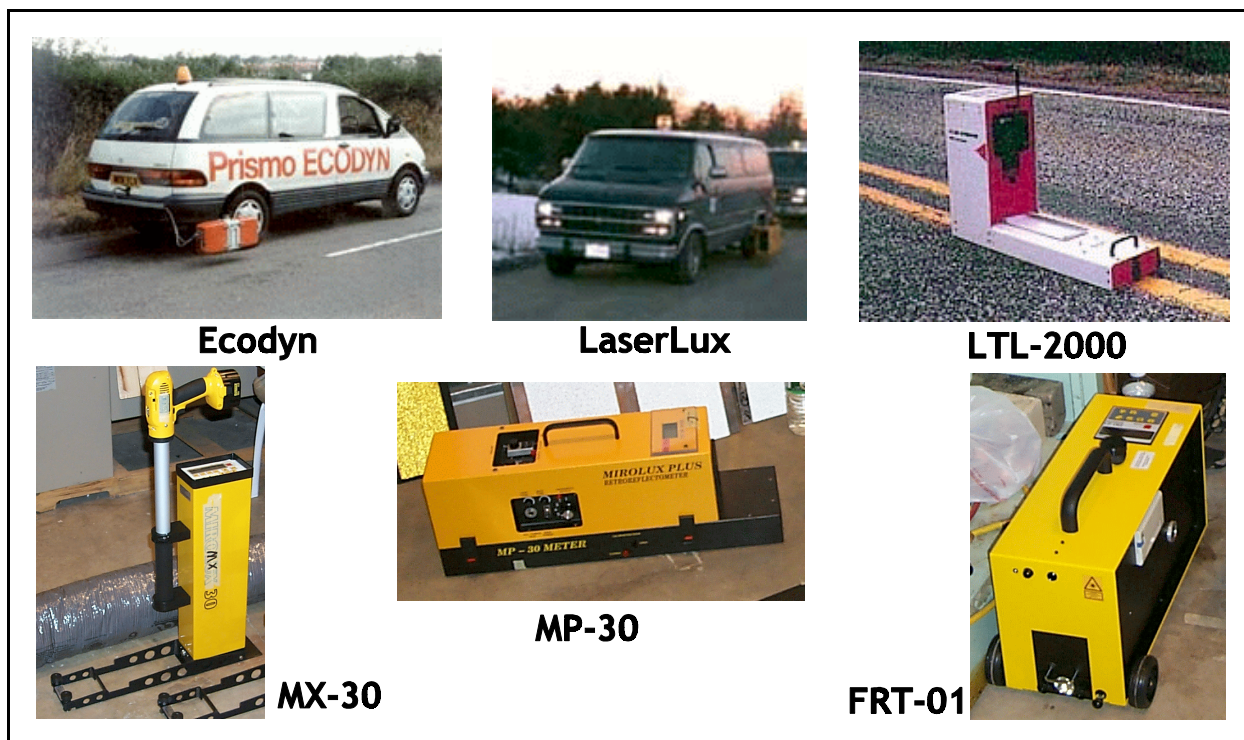
Pavement marking retroreflectometers have been available for many years. In recent years however, there has been a shift from the 12-meter measurement geometry to 30-meter measurement geometry. Figure 3 illustrates the differences between these geometries. In essence, the change was made so that pavement marking retroreflectivity measurements would better represent pavement marking performance at a distance where drivers more typically viewed markings. This is a significant change. Many agencies own several 12-meter instruments and much of the previous research on pavement marking retroreflectivity was conducted using 12-meter instruments. Unfortunately, it is not possible to convert 12-meter marking retroreflectivity to 30-meter values with any level of accuracy. The relationship between the 12- and 30-meter values depend upon the instrument, the beads, and the binder. And even if a conversion could be made, many of the earlier studies do not indicate whether 12- or 30-meter instruments were used in the analysis.



**Figure 3. Comparison of 12-meter and 30-meter Measurement Geometry**

The uncertainty of pavement marking retroreflectivity measurements lead the FHWA to fund a study to compare the performance of commercial pavement marking retroreflectometers. This evaluation was conducted through the Highway Innovative Technology Evaluation Center (HITEC). A panel of experts was created and they developed a plan for evaluating the four handheld and two mobile units. Photos of these units are shown in Figure 4. After the evaluation and analysis was completed, a series of six reports were prepared describing the results ([3](#), [4](#), [5](#), [6](#), [7](#), [8](#)). These reports provide transportation agencies with useful information about the instruments they may be considering for use. While there is no one instrument that is best for any given agency, the report provides information that will help an agency balance accuracy, costs, and efficiency in making a decision.

The ability to accurately measure pavement marking retroreflectivity is a critical element in the overall effort to advance the state of pavement marking performance. The knowledge gained from the HITEC evaluation provides an important step in the process.



**Figure 4. Retroreflectometers Included in HITEC Evaluation**

### **AASHTO Retroreflectivity Task Force**

In November 1998, the FHWA was close to issuing a proposed rule on minimum levels of retroreflectivity for signs when the Board of Directors of the American Association of State Highway and Transportation Officials (AASHTO) requested the FHWA to delay any future action of minimum retroreflectivity levels until an AASHTO Task Force could review the issue and develop recommendations for the FHWA. The AASHTO Retroreflectivity Task Force was created in early 1999 and includes representatives from federal, state, city, and county transportation agencies, industry, research, and private sector perspectives. The Task Force held its first meeting in April 1999 and immediately began to address minimum retroreflectivity for signs. At the most recent meeting on February 29, 2000, the Task Force began to address the issue of minimum levels of retroreflectivity for pavement markings. Upon completing its work, the Task Force intends to submit a resolution to the AASHTO Board of Directors for consideration.

Since the Task Force has not looked at the pavement marking issue in great detail, it is not possible to indicate what the group will recommend. However, based on activity in the signing area, the Task Force may recommend more than one option for meeting the minimum levels of retroreflectivity for pavement markings. The options may include visual inspections tied to calibrated test panels, maximum age for pavement markings based on material and traffic volume, or some other option.

## **National Retroreflectivity Calibration Standard**

At the present time, there is no national calibration standard for retroreflectivity. As a result, there are currently no traceable methods in the United States to determine the accuracy of retroreflectivity measurements. This situation will be addressed in an upcoming research project as part of the National Cooperative Highway Research Program (NCHRP). Project 5-16, National Calibration Standards for Measuring Retroreflectivity, is intended to develop a dedicated reference instrument to provide national calibration standards for retroreflectivity, thereby improving the accuracy of measurements made by other instruments. This reference instrument will use modern instrumentation techniques to perform routine calibrations in compliance with all relevant documentary standards. The instrument will have sufficient flexibility to measure spectral and luminous quantities of both signs and markings over the full range of angles, and will have the best possible accuracy.

## **Final Rule on Centerline and Edge Line Markings**

On January 3, 2000, the FHWA published a final rule that establishes MUTCD requirements for the use of centerlines and edge lines. Table 2 provides a brief overview of this final rule. At the time of the workshops, this final rule had not been issued. Many of the workshop participants were concerned that the requirements of the expected final rule would require significantly greater amounts of pavement markings in their jurisdictions. Appendix B presents the text of this final rule.

## **PAVEMENT MARKING WORKSHOPS**

In moving toward including minimum levels of pavement marking retroreflectivity in the MUTCD, the FHWA wanted to obtain input from public agency personnel on the retroreflectivity values recommended in the FHWA research. This process was considered essential in developing minimum levels of retroreflectivity that would be accepted and implemented by transportation agencies in the United States. Therefore, the FHWA invited representatives from city, county, and state transportation agencies to take part in a series of workshops on minimum levels of retroreflectivity for pavement markings. The workshop participants represented the transportation agency personnel who had significant responsibilities for traffic control devices and implementing MUTCD requirements. This report summarizes the results of these workshops.

- ! Chapter 2 of this report describes the organization and conduct of the workshops.
- ! Chapter 3 describes the night pavement marking retroreflectivity demonstration.
- ! Chapter 4 describes the results of the individual workshops.
- ! Chapter 5 describes the recommendations.

**Table 2. Overview of Final Rule on Centerlines and Edge Lines**

Condition	Shall	Should	May
Centerlines	<p>Center line markings shall be placed on paved, 2-way traveled ways on streets and highways having one or more of the following characteristics:</p> <ol style="list-style-type: none"> <li>1. Urban and rural arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.</li> <li>2. Urban and rural traveled ways with 3 lanes or greater.</li> </ol>	<p>Center line markings should be placed on paved, 2-way traveled ways on streets and highways having the following characteristics:</p> <ol style="list-style-type: none"> <li>1. Urban arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 4000 or greater.</li> <li>2. Rural arterials and collectors with traveled ways 5.4 meters (18 feet) or more in width with an ADT of 3000 or greater.</li> </ol> <p>On traveled ways less than 4.8 meters (16 feet) wide, an engineering study should be used in determining whether to place center line markings on traveled ways due to traffic encroaching on the pavement edges, due to traffic being affected by parked vehicles, and due to traffic encroachment into the lane of opposing traffic where edge line markings are used.</p>	<p>Center line markings may be placed on other 2-way traveled ways on any street and highway.</p>
Edge Lines	<p>Edge line markings shall be placed for paved traveled ways on streets and highways with the following characteristics:</p> <ol style="list-style-type: none"> <li>1. Freeways,</li> <li>2. Expressways, and</li> <li>3. Rural arterials with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.</li> </ol>	<p>Edge line markings should be placed on paved travel ways for streets and highways with the following characteristics:</p> <ol style="list-style-type: none"> <li>1. Rural collectors with traveled ways 6 meters (20 feet) or more in width.</li> <li>2. Other paved streets and highways where engineering study indicates a need.</li> </ol>	<p>Edge line markings may be placed on the traveled way on any other street or highway with or without center line markings. Edge line markings may be excluded based on engineering judgment where the travel way edges are delineated by curbs or other markings.</p>





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## CHAPTER 2

# WORKSHOP ORGANIZATION

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In the fall of 1999, the FHWA conducted a series of three workshops on minimum levels of retroreflectivity for pavement markings. Participation in the workshops was by invitation only and included only government representatives from city, county, and state transportation agencies. During the course of the day and a half workshop, participants were presented with a variety of information on pavement marking retroreflectivity, took part in a nighttime demonstration of pavement marking retroreflectivity, and worked to develop recommendations regarding minimum levels of in-service retroreflectivity for pavement markings.

### WORKSHOP LOCATIONS

Each of the three FHWA-sponsored workshops was hosted by a transportation agency from the area in three widely distributed geographic regions, as described below. For the first workshop, the nighttime retroreflectivity demonstration was held on the evening of the first day. For the other two workshops, the nighttime demonstration was held the night before the first day.

- ! Kent, Washington (outside of Seattle), hosted by the Washington State Department of Transportation. This workshop was held October 5-6, 1999.
- ! Sulphur, Louisiana (near Lake Charles), hosted by the Calcasieu Parish Division of Engineering and Public Works. This workshop was held November 15-17, 1999.
- ! Raleigh, North Carolina, hosted by the North Carolina Department of Transportation. This workshop was held December 6-8, 1999.

### WORKSHOP PARTICIPATION

There were three categories of individuals attending the workshops. The largest of these groups was the participants themselves. A second group was the observers. The third group was the facilitators who were responsible for conducting the workshop.

#### Participants

Each of the workshops was attended by 22 or 23 participants representing city, county, and state transportation agencies. A total of 67 individuals participated in the workshops as participants. Participation in the workshop was by invitation only and only public agency personnel were invited to attend. Appendix C lists the participants that took part in each of the workshops. Table 3 summarizes the representation in each workshop by type of government agency. Table 18 in Appendix C lists the states represented by the local and state transportation agency personnel participating in the workshop. A total of 39 states and Puerto Rico were represented by the city, county, and state agency participants.

**Table 3. Summary of Workshop Participants**

Workshop Location	Number of Participants				Observers
	State	County	City	Total	
Washington	11	10	1	22	3
Louisiana	10	13	0	23	6
North Carolina	15	3	4	22	3
Totals	36	26	5	67	12
Percentage	54%	39%	7%	N/A	N/A

### Observers

At each of the workshops, there were several government representatives who were participating as observers. A total of ten individuals were observers in the three workshops. One of these attended all three workshops. Six of the eleven observers were FHWA employees. Two were from transportation agencies outside the U.S. The other two represented a T<sup>2</sup> center and the American Association of State Highway and Transportation Officials.

### Facilitators

The workshops were organized and facilitated by four individuals. These individuals were responsible for presenting the different portions of the workshops and facilitating discussion among the participants. The facilitators were:

- ! Rick Beck - A Minnesota Department of Transportation employee.
- ! Jim Carlson - A Minnesota Department of Transportation employee.
- ! Gene Hawkins - A consultant to the FHWA.
- ! Greg Schertz - An FHWA employee in the Office of Highway Safety Infrastructure

At the first workshop in Washington, Rick Beck served as a participant representing the Minnesota Department of Transportation. He served as a facilitator in the other two workshops (Louisiana and North Carolina).

### WORKSHOP SCHEDULE

The workshop schedule varied slightly between each of the workshops. In general, there were three elements of the workshops. A full day of presentations by the facilitators, a half day involving some presentations and also the development of recommendations, and a nighttime retroreflectivity demonstration. Table 4 presents a typical schedule for any of the three workshops.

**Table 4. Typical Workshop Schedule**

Time During Workshop		Information Presented
Night Before		Retroreflectivity Demonstration (Louisiana and North Carolina)
First Day	Morning	Introduction, Background, Marking Principles
	Afternoon	Driver Needs, Impacts, Management, Tort Issues
First Night		Retroreflectivity Demonstration (Washington)
Second Day	Morning	Discussion, Recommendations, Conclusions

Note: Workshop schedule varied between each workshop.

At the first workshop in Washington, the night retroreflectivity demonstration was conducted on the night following the full day of presentations. Based on the participants' comments, the night demonstration was changed for the second and third workshops (Louisiana and North Carolina) to take place on the evening before the first day of the workshop. Familiarizing the participants with the relationship between marking appearance and marking retroreflectivity proved to be much more effective when done before the workshop began. Regardless of the evening in which the demonstration was conducted, it lasted for two to three hours. The night demonstration is described in more detail in Chapter 3.

The first day of the workshop was a full day (eight hours). During the first day, the facilitators described the purpose of the workshop and presented background information on pavement marking retroreflectivity. All of this information was pre-prepared by the facilitators. The second day of the workshop was a half day (four hours), with the workshop ending near noon. The focus of the second day was on open discussion and the development of the workshop recommendations, although there was a small amount of pre-prepared information presented by the facilitators. For the Louisiana and North Carolina workshops, the first part of the second day was spent in small group discussions (described later).

In the first workshop, the open discussion and recommendation development took part during the last two hours of the workshop. Feedback from the participants indicated that this was not enough time for all opinions to be heard and adequately considered. In the second and third workshops, the entire second day (four hours) were devoted to discussion and recommendations development.

## **WORKSHOP CONTENT**

The material presented during the daytime portions of the workshop included several modules addressing key issues associated with minimum levels of retroreflectivity. These modules are listed in Table 5.

**Table 5. Summary of Workshop Modules**

<b>Module Title</b>	<b>Description of Module</b>
Introduction	Description of workshop, introduction of participants
Background	MUTCD requirements, Congressional requirements, FHWA activities, related activities
Marking Principles	Retroreflectivity basics, measurement, retroreflectivity geometrics, retroreflectometers, beads
Public Perception of Pavement Markings	Mn/DOT research study on driver perception of pavement marking retroreflectivity
Driver Needs	Headlight performance, older driver issues, research on pavement marking retroreflectivity needs
Marking Management/Processes	Description of Mn/DOT's pavement marking management system, benefits of having a management program or process.
Impacts	Impacts of minimum retroreflectivity on pavement marking replacement and budgets
Tort Issues	Open discussion of key tort-related issues
Recommendations	Open discussion to develop recommendations on minimum levels of retroreflectivity
Conclusions	Summary, future activity, evaluation

**SMALL GROUP DISCUSSION**

Another unique aspect of the second and third workshops was using the first part of the second day to split the participants into small groups. The small group discussion allowed each group to discuss the issues and develop unique recommendations. The full workshop was then reconvened and the small group recommendations were discussed by the full workshop. This was followed by the development of overall recommendations for the full workshop.

**PARTICIPANT INPUT**

Each of the participants had numerous opportunities to provide input to the workshop recommendations. These opportunities included:

- ! A pre-workshop questionnaire,
- ! Comments during the presentation of the workshop modules, during the development of recommendations, and at the very end of the workshop, and
- ! A post-workshop evaluation.

## **Pre-Workshop Questionnaire**

The pre-workshop questionnaire was an eight-page document consisting of 31 questions about agency practices regarding pavement markings. Appendix D contains the questionnaire that was distributed to the workshop participants.

## **During-Workshop Comments**

The participants were encouraged to ask questions and make comments at any time during the course of the workshops. Most of the open discussion took place on the second day, but participants also asked questions and offered the benefits of their experiences during the first day.

At the end of the workshop during the concluding remarks, the facilitators went around the room and asked each of the participants if they had any final comments they would like to offer. This gave everyone a chance to provide input, even if they had not been inclined to do so during the general discussion portions of the workshop.

## **Post-Workshop Evaluation**

The post-workshop evaluation was a two-page document with nine questions. It was distributed to participants in the Louisiana and North Carolina workshops, but not the Washington workshop. Appendix E presents the evaluation form and summarizes the responses to each question for those participants that responded.



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## CHAPTER 3

# NIGHT RETROREFLECTIVITY DEMONSTRATION

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One of the features of the three workshops was a nighttime demonstration of pavement marking retroreflectivity. At the Washington workshop, this demonstration was held on the evening of the first day of the workshop. The Washington workshop participants indicated that the workshop would have more value if the demonstration was held before the first day. So for the Louisiana and North Carolina workshops, the demonstration was held the night before the formal workshop began.

The night demonstration consisted of two elements: a static observation and a dynamic observation. In the static observation, participants viewed a set of fabricated markings from a stationary vehicle. In the dynamic observation, participants viewed actual field markings from a moving vehicle. In both types of observations, participants were asked to rate the quality of the marking.

The actual retroreflectivity values of the markings observed in the static and dynamic observations were not revealed to the participants until after the night demonstration was completed. Most of the participants had never been involved in the measurement of pavement marking retroreflectivity, so the night demonstration provided a purely subjective evaluation of marking performance. It also served to familiarize the participants with the relationship between visual appearance of a marking and its retroreflectivity value.

The night demonstration was not intended to define the minimum level of retroreflectivity needed by road users. In order to complete the demonstration within a reasonable time period (generally about 2½ hours), numerous compromises were made. Examples of these compromises include: making the static observations from a stationary vehicle, providing unlimited time for the observations, locating the participants in the dynamic observation in positions throughout a 15-passenger van, and not placing any driving tasks on the participants. Due to these and other compromises in the procedural aspects of the night demonstration, the results should not be viewed as a scientific evaluation of the minimum level of retroreflectivity needed for adequate pavement marking performance.

### STATIC OBSERVATION

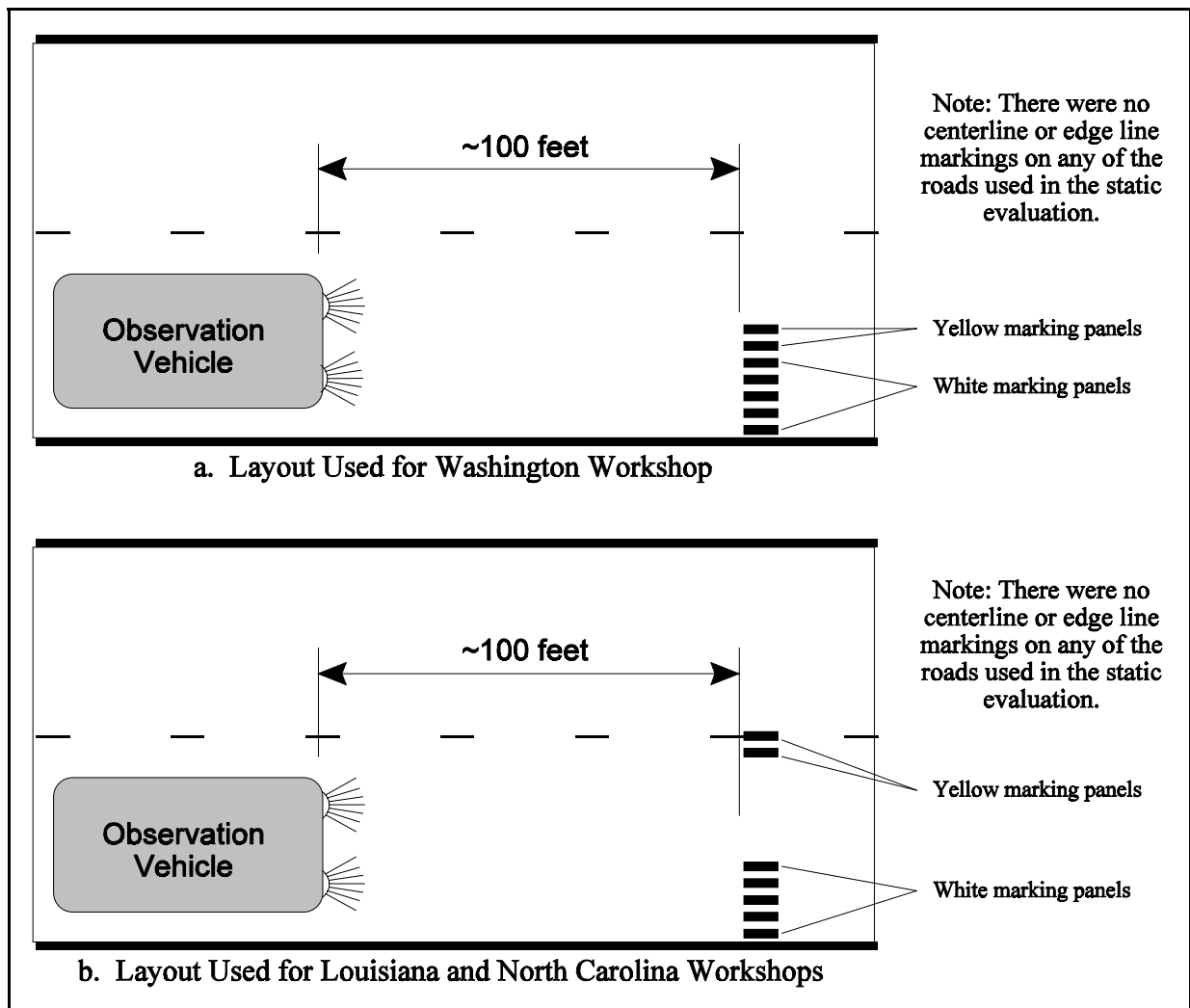
In the static observation, participants viewed aluminum panels with retroreflective markings that provided a range of retroreflectivity for both yellow and white markings. This provide a consistent manner of presenting pavement marking retroreflectivity from one workshop to another.

#### Procedure

The markings used for the static observation were a set of seven black aluminum panels that were 6 inches wide and 2 feet long. A 4-inch marking ran the length of the panel. Each of the

panels provided different levels of retroreflectivity. There were five white panels with retroreflectivity between 65 and 1,100 mcd/m<sup>2</sup>/lux and two yellow panels with retroreflectivity levels of 90 and 200 mcd/m<sup>2</sup>/lux. All retroreflectivity measurements represent a 30 meter geometry. The set of panels was provided by the 3M Corporation and the same set of panels was used in all three workshops.

For the static observation, a remote or private site was utilized with little or no traffic. The seven panels were placed on the pavement approximately 100 feet in front of the stationary observation vehicle. Figure 5 illustrates the layout of the static observation for the three workshops. The order of the panels within a given color was randomized. The participants then sat in the driver’s seat of a stationary vehicle one-at-a-time and observed the panels, assigning each panel a rating of “satisfactory,” “marginal,” or “unsatisfactory.”



**Figure 5. Static Observation Layout**



## Results

The results of the static nighttime observations are summarized in Table 6. As can be seen from this table, the white markings did not have a high level of “*satisfactory*” ratings until the retroreflectivity was greater than 280 mcd/m<sup>2</sup>/lux. For the panels with retroreflectivity levels of 680 and 1,100 mcd/m<sup>2</sup>/lux, the “*satisfactory*” ratings were at or near 100 percent. The white panels with retroreflectivity levels of 65 and 110 mcd/m<sup>2</sup>/lux were rated as “*satisfactory*” by only one participant.

For the yellow markings, only the 200 mcd/m<sup>2</sup>/lux panel at the Washington workshop has a “*satisfactory*” rating of 100 percent. The 90 mcd/m<sup>2</sup>/lux yellow panel was also rated higher in the Washington workshop than in the other two. These higher ratings for the yellow markings in Washington can be attributed to the fact that both were positioned near the right side of the road, instead of near the centerline as was done in the other two workshops. Figure 5 illustrates this placement.

**Table 6. Summary of Observations of Marking Panels**

Marking Color	Actual Retroreflectivity	Percent of Participants Selecting a Rating								
		Washington			Louisiana			North Carolina		
		Sat	Marg	Unsat	Sat	Marg	Unsat	Sat	Marg	Unsat
White	65	0	20	80	4	4	92	0	0	100
White	110	0	60	40	0	29	71	0	6	94
White	280	35	65	0	38	54	8	11	89	0
White	680	100	0	0	83	13	4	100	0	0
White	1100	95	5	0	100	0	0	100	0	0
Yellow	90	30*	50*	20*	0	33	67	0	22	78
Yellow	200	100*	0*	0*	38	54	8	50	44	6

Notes: \*Yellow marking located near the center of the travel lane.  
 Sat = Satisfactory, Marg = Marginal, and Unsat = Unsatisfactory.  
 All retroreflectivity measurements are mcd/m<sup>2</sup>/lux and were made with a 30 meter instrument.

## DYNAMIC OBSERVATIONS

In dynamic observation, participants observed actual pavement markings on the road while riding in a van. The markings included yellow centerlines and white edge lines. The observations were made while the vehicle was moving, with the participants/observers located in various positions within the van.

## Procedure

The values of the pavement markings viewed in the dynamic observation were measured by the host agency prior to the night demonstration. All markings were measured using 30 meter instruments. As the participants were driven on the selected roads in a large 15-passenger van, the driver would identify locations where the markings were to be observed. As they observed the markings in the identified section, they would assign a rating of “*satisfactory*,” “*marginal*,” or “*unsatisfactory*,” just as had been done with the static observation. The participants were not responsible for driving the vehicle at any time during the observations. Some of the participants were located in the rear seats of the van, which may have produced an artificially lower subjective evaluation of the marking acceptability.

The markings that were part of the dynamic observation represented a wide variety of materials and retroreflectivity. In the Louisiana workshop, the area of the marking identified for observation was only a few feet long, while it was an extended distance for the other two workshops. This allowed the Louisiana participants to rate the marking when it was only a short distance in front of the vehicle. This also enabled the participants to view the marking with higher illumination than at 30-meter geometry, which may have produced an artificially higher subjective evaluation.

## Results

The results of the dynamic observation are provided in Table 7. As can be seen from this table, there were not many markings in the dynamic observations with retroreflectivity levels near the minimum levels initially recommended by the FHWA research. These results indicate inconsistent evaluations of the pavement marking retroreflectivity. There were several markings with high levels of retroreflectivity (for white markings, 143 in Washington, 224 in Louisiana, and 263 in North Carolina) which received ratings lower than would otherwise be expected. Due to the non-scientific nature of the observation procedure, it is not possible to identify the reasons for these inconsistencies.

## USE OF DEMONSTRATION RESULTS

Although the tables in this chapter present the results of the static and dynamic demonstrations of pavement marking retroreflectivity, these results should not be used in the development of recommendations for minimum levels of in-service retroreflectivity for pavement markings. The demonstrations were not conducted in a scientific manner and do not represent drivers needs for pavement marking visibility. It should be remembered that the demonstrations were conducted to familiarize the workshop participants with the visual appearance of markings at various levels of retroreflectivity. The demonstrations were not conducted to identify acceptable values for minimum levels of in-service retroreflectivity.

**Table 7. Results of Field Evaluations**

White Markings					Yellow Markings				
Location	Actual Value	Percent of Participants			Location	Actual Value	Percent of Participants		
		Sat.	Marg	Unsat			Sat	Marg	Unsat
NC	58	22	61	17	LA	38	29	42	29
WA	78	75	25	0	NC	38	17	44	39
WA	98	90	10	0	WA	47	20	70	10
LA	133	88	8	4	LA	68	67	25	4
WA	143	60	40	0	LA	80	54	29	16
LA	191	100	0	0	WA	81	60	35	5
WA	221	100	0	0	NC	119	89	11	0
LA	224	42	46	13	LA	156	83	16	0
NC	243	100	0	0	LA	163	92	8	0
NC	263	83	17	0	NC	173	72	28	0
NC	526	100	0	0	WA	218	100	0	0
WA	705	100	0	0	NC	279	89	11	0

Notes: Sat = Satisfactory, Marg = Marginal, and Unsat = Unsatisfactory.  
 All retroreflectivity measurements are mcd/m<sup>2</sup>/lux and were made with a 30 meter instrument.



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## CHAPTER 4

# SUMMARY OF WORKSHOP RESULTS

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Each of the workshops consisted of two basic portions. The first portion was the presentation of information by the workshop facilitators as described in the previous chapter. The second portion was the group discussion of related issues and the development of recommendations for the FHWA to consider. In the Washington workshop, about 90 minutes was spent at the end of the workshop discussing the recommendations. This was found to be too short, and about 3½ hours were spent on the recommendations in the Louisiana and North Carolina workshops. In each of these last two, participants were split into small groups first. Each of the small groups discussed the issues and developed initial recommendations on their own. Each of the small group recommendations were presented to the workshop as a whole. Following the small group presentations, the workshop participants then discussed the issues and developed the overall workshop recommendations. The recommendations of previous workshops were not revealed to the participants at any workshop until after the workshop was completed.

Participants in each of the three workshops provided different perspectives on the issue of minimum levels of retroreflectivity for pavement markings. This chapter describes the recommendations from each workshop regarding minimum values for pavement marking retroreflectivity and other related issues. For each workshop, the recommendations are divided into three categories: minimum value recommendations, guideline structure, and related issues. A main focus of the workshops was developing recommendations for specific minimum values of pavement marking retroreflectivity. These recommendations represent values that the participants would feel comfortable with based on the information presented in the workshop (including the night demonstration) and their knowledge of their agency's pavement marking practices. Another focus was developing a structure and partial content into which the minimum values could be incorporated. This typically related to the MUTCD language for the minimum values. Finally, the participants also identified other issues related to the minimum values or additional information that is needed to develop acceptable guidelines for minimum levels of retroreflectivity to improve safety.

### COMMON WORKSHOP ISSUES AND CONCERNS

Each of the workshops resulted in distinct findings and recommendations regarding minimum levels of retroreflectivity. However, there were common threads that ran through all three workshops. These are described below as they apply to all three workshops. If a specific workshop had recommendations or additional information that apply to a general concern, that information is provided as part of the individual workshop descriptions.

#### Standard Versus Guideline

The language in the Department of Transportation Appropriations Act requires the MUTCD to be revised “to include a minimum standard of retroreflectivity” [emphasis added]. One of the concepts that was difficult for the participants to understand was the FHWA's interpretation of

the word “standard” as used in the legislation. The FHWA has determined that the MUTCD, as a whole, is considered a standard. By putting a minimum retroreflectivity requirement in the MUTCD, the FHWA has satisfied the legislative requirement for a standard, even if the actual language of the requirement in the MUTCD does not use a shall statement (a standard). In other words, the minimum retroreflectivity values in the MUTCD can be presented as a standard (shall) or guidance (should) statement and either will satisfy the requirements of the Congressional legislation.

The workshop participants were unanimous in stating that any minimum retroreflectivity values in the MUTCD for pavement markings should be worded as a guidance (should) statement. Several commented that an option (may) statement would be even better, but recognized that such a statement would provide little incentive for agencies to improve the nighttime performance of their markings.

### **Guideline Structure**

Even if the minimum retroreflectivity values are included in the MUTCD as a guidance statement, the participants expressed concern over the wording and structure of the minimum values. They indicated that the structure and wording of the guidelines was just as important as the values of the minimums themselves. The key elements of any potential guideline for minimum levels of pavement marking retroreflectivity are (in no particular order):

- ! **Numerical values** - What are the minimum values and how are they structured?
- ! **Wording** - What is the actual language contained in the MUTCD?
- ! **Application** - What markings do the minimum values apply to and when do they apply?
- ! **Measurement requirements** - How is compliance with the minimums determined, how many markings need to be measured, and how are markings measured?
- ! **Exceptions** - What are the exceptions that would modify or eliminate the application of the minimum values.
- ! **Corrections** - What does an agency need to do if marking retroreflectivity falls below the minimum levels?

To the extent possible, the workshop participants tried to address many of these issues in the short time available to develop the workshop recommendations. However, there was not sufficient time nor information available to address all of the issues.

### **Tort Liability**

The most common complaint voiced during the workshops was that establishing minimum retroreflectivity levels for pavement markings would increase the potential for tort claims against the agencies. The participants in all three workshops were in agreement that it was desirable to provide road users with the best possible markings. However, the participants expressed numerous concerns regarding how minimum performance requirements for pavement markings would affect the agencies, especially at the local level. Participants indicated that lawsuits against transportation agencies have become a steady drain on the resources of transportation agencies and are diverting resources from important needs. While participants felt that they

could defend against many of these lawsuits, such defenses consume time and resources that would be better devoted to fulfilling the public's needs. And the increased exposure to tort claims does not apply only to agencies with poor markings. The participants felt that even agencies with good markings would have a greater chance of being sued than exists at the present time.

At the end of each workshop, one of the facilitators asked the participants as a group whether it would be possible to develop minimum levels of retroreflectivity in such a way that it would not increase an agency's tort exposure. There was general agreement that such an objective could be accomplished, but would require language that provide agencies with significant flexibility to meet the target values.

### **Agency Burdens**

In addition to the tort liability issues, the workshop participants were concerned about the other burdens that minimum levels of retroreflectivity would place on transportation agencies. The first burden is the need to measure all of the markings in the jurisdiction. Very few of the agencies present at the workshops currently measure the retroreflectivity of their markings. Most agencies do not even have a pavement marking retroreflectometer in the agency. Putting measurement-based minimum retroreflectivity levels in place would require agencies to divert resources from current programs to buying equipment and reallocating staff.

A further drain on agency resources is the burden associated with establishing a program for complying with the minimum values. Even if an agency is able to overcome the challenges associated with providing markings that meet the minimum values, there could be a significant burden associated with providing the administrative framework needed to ensure compliance. The administrative burden includes providing a means of documenting activities associated with pavement marking retroreflectivity, ensuring that retroreflectivity measurements are accurate and consistent over time, and that adequate resources are devoted to pavement marking activities.

One of the common complaints voiced by the participants from local agencies was that establishing minimum levels of retroreflectivity for pavement markings was another unfunded federal mandate. Several participants from local agencies indicated that the federal government continues to place more and more requirements on how they go about conducting business at the local level. Each time one of these new requirements is placed on a local agency, it reduces the agency's ability to address the "real" problems that exist at the local level. In essence, the local agency representatives were stating that the problems that federal requirements are intended to address may not exist at the local level. Local agencies need to have the freedom to make decisions to address the problems that exist at their specific level.

### **Measured System**

In developing the minimum retroreflectivity recommendations in each workshop, the participants wanted to provide agencies with multiple options for complying with the minimum values. In the first workshop, the term "measured system" was coined to represent the concept

that there are multiple options for providing pavement markings that comply with the minimum retroreflectivity levels.

All of the participants recognized that one option for complying is to measure the retroreflectivity of all or a sample of the pavement markings in a jurisdiction. While some agencies may be able to accomplish this, many of the participants wanted to have the ability to use other methods of ensuring compliance. The most commonly mentioned option was a visual inspection program. However, to qualify as part of a “measured system,” the visual inspection needs a tie to the minimum values. This might be accomplished through the use of calibrated panels or other method that ensures the visual inspection will identify markings below the minimum levels of retroreflectivity.

Another possible option for complying with minimum values is through marking replacement at established intervals. The intervals are selected to ensure that markings are replaced before reaching the minimum levels. The disadvantage of such a system is that some markings may be replaced while still possessing a significant amount of retroreflectivity. Other options that could be used in a measured system are contractor monitoring and replacement of markings or contracting with an independent contractor to measure pavement marking retroreflectivity.

Regardless of which option is used, the concept of a measured system requires a documented plan that indicates how the agency is complying with the minimum retroreflectivity levels. The documented plan should be detailed enough to allow an agency to use it to defend against tort claims.

### **Reductions in Minimums When Supplemental Devices Present**

The FHWA research recommendations indicate that the minimum retroreflectivity values can be reduced if retroreflective raised pavement markers are present. Participants in all three workshops agreed with the concept that minimums for markings should be reduced if supplemental devices are present. However, there were differences between the workshops on what devices would provide exceptions and how much the retroreflectivity values should be reduced when the devices are present. Examples of supplemental devices that were identified in one or more workshops included: retroreflective raised pavement markers, continuous roadway lighting, or roadway delineation.

An apparent contradiction in the FHWA minimum retroreflectivity research recommendations is the ability to reduce the minimum values if retroreflective raised pavement markers are present, but not providing any performance requirement for the quality of the retroreflective raised pavement markers. The participants wanted to know how an exception to a numerical requirement can be established if the exception has no numerical or performance level associated with it. Any minimum retroreflectivity guidelines developed by FHWA need to establish a performance requirement for any supplemental devices that are used to reduced the minimum values.



## Categories for Minimum Retroreflectivity Levels

All three workshops provided retroreflectivity guidelines that were a function of speed, with three categories of speeds. The Louisiana workshop also provided a separate set of guidelines that established minimum levels as a function of functional classification. The North Carolina workshop established distinct minimums for freeways above those in the high speed category. Traffic volume was not recommended by any of the workshops.

Even though all three workshops recognized the appropriateness of speed-based retroreflectivity criteria, there were differences in what those criteria should be. Table 8 summarizes the speed categories recommended by each of the workshops. As can be seen from the table, the point of contention between the workshops was the speed at which the minimum levels changed from the middle category to the high category. Speeds between 45 and 60 mph were recommended by the participants.

**Table 8. Speed-Based Criteria for Minimum Retroreflectivity Levels by Workshop**

<b>Workshop</b>	<b>Low</b>	<b>Middle</b>	<b>High</b>	<b>Highest</b>
Washington	≤ 30 mph	35-50 mph	≥55 mph	None
Louisiana	≤ 30 mph	35-55 mph	≥60 mph	None
North Carolina	≤ 30 mph	35-40 mph	Non-Freeway ≥45 mph	Freeway

The local agencies at the workshops (almost all county agencies) indicated that their roads included many miles of rural roadways with speed limits of 55 mph. However, most of these roads have low traffic volumes. These participants felt that it was inappropriate to require the same level of retroreflectivity for these roads as required for freeways and state highways.

### WASHINGTON WORKSHOP

Approximately 90 minutes at the end of the workshop in Washington state were devoted to the development of recommendations and identification of key issues. There were no small group discussions in the Washington workshop as there were with the other two workshops. During this time, the participants agreed upon recommended minimum values that were largely acceptable to the group, identified factors to be addressed in the development of the guidelines, and identified key issues for which more information needs to be provided.

### Minimum Value Recommendations

Table 9 presents the recommendations of the Washington workshop regarding the minimum values of retroreflectivity for pavement markings.

**Table 9. Recommended Minimums from Washington Workshop**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	≤ 30 mph	35-50 mph	≥55 mph
White	Presence <sup>3</sup>	80	100
Yellow	Presence	60	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking, but with no retroreflectivity value.

$R_L$  is based on the marking only, and does not account for impacts of RRPMs or ambient lighting.

The minimum values may be reduced if supplemental devices (such as retroreflective raised pavement markers, delineators, or lighting) are used.

**Guideline Structure**

In developing the minimum values shown in the preceding table, the workshop participants offered the following comments regarding the structure associated with the minimum value guidelines.

- ! Any requirements that the FHWA establishes in the MUTCD for minimum pavement marking retroreflectivity should be worded as guidelines (should) and not a standard (shall).
- ! The language associated with the minimum values should state: “Agencies should provide markings that meet the average retroreflectivity values in Table 9 as measured by a “measured system.”
  - ▶ The term “average retroreflectivity values” was used to indicate that an aggregate of pavement markings should meet the minimum values. Participants do not want to have the minimum values apply to a single marking or a portion of a single marking. Retroreflectivity values should be measured over a substantial length of marking(s).
  - ▶ The term “measured system” was coined in the workshop to represent a process for ensuring that pavement markings would meet the nighttime visibility needs of road users. Elements of a measured system are discussed in the Related Issues section of the Washington workshop. Potential measurement systems identified by the workshop participants included:
    - A representative sample of pavement marking retroreflectivity measurements.
    - Visual inspections based on specific evaluation criteria such as a distance from the marking or travel time from the marking. Factors such as the age and visual characteristics of the inspector should be considered as part of the evaluation criteria.
- ! Where the retroreflectivity of markings falls below the values in Table 9, agencies should schedule replacement of the markings as soon as conditions and resources permit.

- ! There should be the ability to reduce the minimum values in Table 9 if supplemental devices are used. Examples of supplemental devices identified by the participants included: retroreflective raised pavement markers, delineators, and lighting. The workshop participants felt that there was not enough available information on the impacts of retroreflective raised pavement markers and lighting to determine how much the minimum levels of retroreflectivity could be reduced.
- ! The proposed rule should address issues such as the use of a process for maintaining minimum levels of retroreflectivity and management of pavement markings as a system.
- ! Pavement marking retroreflectivity values should only be measured under the following conditions:
  - ▶ Dry, clean pavement. Accurate retroreflectivity measurements cannot be made on wet pavement. Agencies should be able to remove foreign matter from the marking surface that may interfere with the retroreflectivity measurement.
  - ▶ Determined annually. Harsh weather conditions may cause pavement marking retroreflectivity to degrade to a larger extent than anticipated by agencies. This typically occurs in areas where snowplowing occurs. Severe winters may cause more snowplowing than originally expected, with a resulting decrease in pavement marking retroreflectivity. When this occurs, agencies typically cannot replace the markings until spring, when pavement and weather conditions are conducive to applying pavement markings. Other conditions may also degrade pavement marking retroreflectivity during certain times of the year. It is not always possible to provide adequate retroreflectivity 365 days a year. Agencies should only need to meet the minimum retroreflectivity values on a yearly basis. The time of year that a marking is measured should be determined by the agency.
- ! Agencies should conduct an annual nighttime visual inspection.
- ! The guidelines developed by the FHWA should address the following issues:
  - ▶ Sampling of retroreflectivity measurements.
  - ▶ Process that can be used to ensure adequate pavement marking retroreflectivity.
- ! In addition to the minimum values, any language in the MUTCD (or a supporting specification) should address sampling requirements.

## **LOUISIANA WORKSHOP**

The entire second morning of the Louisiana workshop was devoted to developing recommendations and concluding the workshop. For approximately the first hour and a half of the morning, participants were split into three small groups. Each group discussed the issues and developed recommendations within their group. Then the entire workshop was reconvened and each group presented their small group recommendations. This took about 30 minutes. Then the next hour and a half was spent discussing the issues and developing overall recommendations for the workshop. During this time, the participants agreed upon minimum values acceptable to most of the participants and other related issues. The concluding remarks took the last half hour of the workshop. The information presented in this section of the report represents the recommendations of the overall workshop.

## Minimum Value Recommendations

The Louisiana workshop was the only workshop that prepared two different sets of minimum values. One set, as indicated in Table 10, presents the minimums as a function of roadway speed. The other set, as indicated in Table 11, presents the minimums as a function of the functional classification of the roadway. The values in the two tables are identical. The only difference is in how the minimums are categorized. The Louisiana workshop participants felt strongly that speed alone was not sufficient for determining which levels of retroreflectivity should apply to a given roadway.

**Table 10. Recommended Minimums from Louisiana Workshop - Based on Speed**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	≤ 30 mph	35-55 mph	≥60 mph
White	Presence <sup>3</sup>	75	100
Yellow	Presence	50	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking, but with no retroreflectivity value.

**Table 11. Recommended Minimums from Louisiana Workshop - Based on Classification**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	All Others	Arterial and Major Collector	Freeway and Expressway
White	Presence <sup>3</sup>	75	100
Yellow	Presence	50	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking, but with no retroreflectivity value.

## Guideline Structure

Initially, the Louisiana workshop participants were supporting the use of artificially low retroreflectivity values for the low-speed/low-classification roadways. In essence, they did not see a need for any significant level of retroreflectivity for this type of roadway. As the workshop participants reached agreement on this issue, the facilitators raised the concept of “presence” markings without indicating that it had been discussed in the previous workshop.

In developing the minimum values shown in the preceding two tables, the Louisiana workshop participants offered the following comments regarding the structure associated with minimum value guidelines.

- ! Any requirements that the FHWA establishes in the MUTCD for minimum pavement marking retroreflectivity should be worded as guidelines (should) and not a standard (shall).
- ! Using a “measured system,” agencies should provide pavement markings that meet the  $R_L$  values in Table 10 or Table 11.
- ! A measured system can be any one or more of the following:
  - ▶ Retroreflectivity measurement of markings that are a representative sample of all the markings in a jurisdiction.
  - ▶ A pavement marking management system.
  - ▶ A nighttime inspection. Visual inspectors should have a means of tying marking visibility to the values in Table 10 or Table 11.
- ! Markings should be measured or evaluated only on clean and dry pavement.
- ! The measured system should be based on an annual evaluation of pavement markings.
- ! If retroreflective raised pavement markings (RPMs) are provided on the roadway, then the values in Table 10 or Table 11 should be reduced to 50 percent of those shown.
- ! The compliance date for meeting minimum levels of retroreflectivity is 10 years.
- ! Where  $R_L$  markings fall below the values in Table 10 or Table 11, the marking(s) should be scheduled for replacement as soon as conditions and resources permit.

## **NORTH CAROLINA WORKSHOP**

The final day of the North Carolina workshop was organized in the same manner at the Louisiana workshop, except that the participants were divided into only two groups. After approximately an hour of small group discussion, the full workshop was reconvened and each group presented its recommendations. The participants then developed the overall workshop recommendations and identified other relevant issues. The information presented in this section of the report represents the recommendations of the overall workshop.

### **Minimum Value Recommendations**

Table 12 presents the recommendations of the North Carolina workshop regarding the minimum values of retroreflectivity for pavement markings. The North Carolina workshop was the only one that had four categories of minimum levels of pavement marking retroreflectivity. The highest category, for freeways, was based only on functional classification and had no speed criteria associated with it.

**Table 12. Recommended Minimums from North Carolina Workshop**

Marking Color	Average Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>			
	≤ 30 mph	35-40 mph	Non-Freeway ≥ 45 mph	Freeway
White	Presence <sup>3</sup>	65	85	100
Yellow	Presence	45	55	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking, but with no retroreflectivity value.

**Guideline Structure**

In developing the minimum values shown in the preceding two tables, the North Carolina workshop participants offered the following comments regarding the structure associated with minimum value guidelines.

- ! Any requirements that the FHWA establishes in the MUTCD for minimum pavement marking retroreflectivity should be worded as guidelines (should) and not a standard (shall).
- ! An agency should implement a pavement marking inspection or maintenance program appropriate to comply with the minimum retroreflectivity values in Table 12.
- ! Compliance with the values in the table shall be determined from an average retroreflectivity value of a marking as determined by the agency.
- ! Relative to pavement marking retroreflectivity measurement, the following issues are to be defined by the agency responsible for the markings:
  - ▶ Condition of pavement when measuring.
  - ▶ Frequency of measuring.
  - ▶ Sample size and sampling procedure.
  - ▶ Measurement method.
- ! If continuous roadway lighting is present, the minimum retroreflectivity values may be 50 percent of the values in Table 13.
- ! If retroreflective raised pavement markers (RRPMs) are present, the minimum values may be reduced by 50 percent for those lines that contain the RRPMs.
- ! The compliance period for meeting the minimum values is five years.
- ! Where retroreflectivity of markings fall below the values in the table, agencies should schedule replacement of the markings as soon as conditions and resources permit.
- ! Minimum retroreflectivity values will not be required where physical and environmental conditions are shown to make compliance impractical.
- ! Minimum retroreflectivity values apply to longitudinal markings only.
- ! Minimum values apply only to markings that are required by the MUTCD (shall or should condition).

## SUMMARY OF WORKSHOP RECOMMENDATIONS

In general, there was a great deal of similarities between the recommendations of the three workshops. Table 13 provides a comparison of the minimum values recommended in the three workshops. This table shows that all three workshops felt that only a presence line was needed on the lowest speed roadways. All three workshops also defined the lowest speed category as 30 mph and slower. All three workshops also had the same retroreflectivity values for the high speed categories, although there were differences in what a high speed roadway was. For white markings, the highest retroreflectivity value was 100 mcd/m<sup>2</sup>/lux. For yellow, it was 80. A significant issue was where a 55 mph road should fit within the guidelines. Many of the local agency personnel indicated that they had arterial roads with speeds of 50 mph and higher. They felt that since these roads function as local roads and not highways, they should not have to meet the highest retroreflectivity values. Finally, it should be noted that the Louisiana workshop also developed values based on functional classification that could be used as an alternative to the speed-based criteria.

**Table 13. Comparison of Workshop Recommendations for Minimum Retroreflectivity**

Marking Color	Speed Category	Washington		Louisiana <sup>1</sup>		North Carolina	
		Speed <sup>2</sup>	R <sub>L</sub> <sup>3</sup>	Speed <sup>2</sup>	R <sub>L</sub> <sup>3</sup>	Speed <sup>2</sup>	R <sub>L</sub> <sup>3</sup>
White	Low	≤ 30 mph	Presence <sup>4</sup>	≤ 30 mph	Presence <sup>4</sup>	≤ 30 mph	Presence <sup>4</sup>
	Middle	35-50 mph	80	35-55 mph	75	35-40 mph	65
	High	≥ 55 mph	100	≥ 60 mph	100	Non-freeway ≥ 45 mph	85
	Highest <sup>5</sup>	---	---	---	---	Freeway	100
Yellow	Low	≤ 30 mph	Presence <sup>4</sup>	≤ 30 mph	Presence <sup>4</sup>	≤ 30 mph	Presence <sup>4</sup>
	Middle	35-50 mph	60	35-55 mph	50	35-40 mph	45
	High	≥ 55 mph	80	≥ 60 mph	80	Non-freeway ≥ 45 mph	55
	Highest	---	---	---	---	Freeway	80

**Notes:**

<sup>1</sup> The Louisiana workshop developed an alternative table based on functional classification using the same R<sub>L</sub> values.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> R<sub>L</sub> is in mcd/m<sup>2</sup>/lux measured at 30 meter geometry.

<sup>4</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

<sup>5</sup> The “Highest” speed category was developed in only one workshop.

R<sub>L</sub> is based on the marking only, and does not account for impacts of RRPMS or ambient lighting.

The minimum values may be reduced if supplemental devices (such as retroreflective raised pavement markers, delineators, or lighting) are used.

The workshop recommendations indicated a willingness to accept a higher yellow/white ratio than used in the FHWA research recommendations. In the FHWA recommendations, the yellow values are 65 percent of the white values. The yellow/white ratios that result from the workshop recommendations range from 65 to 80 percent.

Table 14 summarizes the recommendations from the three workshops regarding the structure of the guideline language in the MUTCD. The guideline issues identified in the table represent general concepts and not the specific language developed in any one workshop.

**Table 14. Comparison of Workshop Recommendations for Guideline Structure**

Guideline Issue	Workshop		
	WA	LA	NC
MUTCD language should be guidelines (should statement) and not a standard (shall).	✓	✓	✓
The minimum values are not intended to establish a 365-day a year requirement for pavement marking visibility. Marking retroreflectivity can be measured on an annual basis or more frequently as defined by the agency.	✓	✓	✓
Minimum values should not be applied to a single reading on a single marking.	✓		✓
Retroreflectivity values should represent an average of portions of the marking system.	✓		✓
Marking retroreflectivity should be measured only under dry and clean conditions	✓	✓	✓
Guidelines are needed on sampling requirements associated with measuring marking retroreflectivity.	✓		✓
Besides retroreflectivity measurements, there should be other alternatives for ensuring markings meet minimum retroreflectivity guidelines. Potential alternatives include visual inspections, measuring a representative sample of the agency's markings, the expected marking life, or a pavement marking management system.	✓	✓	✓
Visual inspections should have a means of relating visual appearance to the minimum retroreflectivity values.		✓	
When markings do not meet the minimum values, the MUTCD language should provide agencies with some leeway to replace markings when conditions and resources permit.	✓	✓	✓
Minimum values can be reduced if supplemental devices are present.	✓	✓	✓
Agencies should conduct an annual visual inspection of pavement marking nighttime visibility.	✓		
Vision characteristics of inspectors should be considered when performing an inspection of marking retroreflectivity.	✓		
Information should be provided on processes for maintaining minimum retroreflectivity and managing pavement markings as a system.	✓		
An extended compliance date should be provided.		✓	✓
Minimum values not applied to markings where physical or environmental conditions make compliance impractical.			✓
Minimum retroreflectivity values apply to longitudinal lines only.			✓
Minimum retroreflectivity values apply only to lines required by the MUTCD (shall or should requirement).			✓



Of particular significance in the workshop was a recommendation that the MUTCD language should include a statement that markings which fall below the minimum should be replaced as soon as conditions and resources permit. The most critical aspect of this is the concern that without such a statement, agencies would have to replace markings in the middle of winter if the existing markings fell below the minimums. Agencies have learned that it is not possible to apply markings in winter conditions, or if applied, the markings do not perform adequately.



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## CHAPTER 5

# FINDINGS AND RECOMMENDATIONS

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The previous chapters describe a series of three, FHWA-sponsored, workshops on minimum levels of in-service retroreflectivity for pavement markings. The purpose of the workshops was to solicit input from city, county, and state transportation agencies regarding the minimum levels of in-service pavement marking retroreflectivity. These three workshops provided two major benefits to the sponsor and the participating agencies:

- ! The FHWA was able to identify the transportation agencies' concerns, impacts, and limiting factors associated with the implementation of minimum levels of retroreflectivity for pavement markings, and
- ! The participating agencies were able to contribute to the process of developing the structure and content for minimum levels of retroreflectivity for pavement markings.

The workshops were generally well-received by the participants, and appreciated as an opportunity to comment on the concept of minimum retroreflectivity for pavement markings. However, in spite of an appreciation for an opportunity to comment, a significant portion of the workshop participants remained opposed to the concept of establishing minimum pavement marking retroreflectivity requirements. Even so, the participants worked together to overcome differences of opinion and develop recommendations for minimum levels of retroreflectivity. This chapter summarizes the key findings resulting from the workshops and offers a series of recommendations for the FHWA to consider in developing a proposed rule for the *Federal Register*.

The conclusions and recommendations described in this chapter reflect those of the four workshop facilitators, based solely on the input received from the workshop participants. The recommendations do not necessarily include specific consideration of previous research on pavement marking retroreflectivity or other factors, nor do they represent the recommendations the facilitators might offer if not restricted to interpreting the workshop results.

### WORKSHOP FINDINGS

Each of the workshops shared numerous similarities while, at the same time, providing some unique differences. The key findings that cut across all of the workshops are described below. They are not listed in any particular order.

- ! A total of 67 individuals representing transportation agencies participated in the three workshops. Of these 67, 5 (7 percent) represented cities, 26 (39 percent) represented counties, and 36 (54 percent) represented states.
- ! Every participant in the three workshops indicated that the guidelines should be structured as a guideline (should), not as a standard (shall).
- ! As a rule, participants from the county agencies were strongly opposed to the concept of minimum levels of retroreflectivity for pavement markings. Participants from the state

agencies were more accepting of the concept, but concerned about the burdens that such minimums would place on their agencies.

- ! As a whole, the participants from all the workshops felt that the minimum retroreflectivity guidelines to be proposed by the FHWA should provide more than one option for ensuring adequate nighttime retroreflectivity of pavement markings. The concept of multiple compliance procedures was characterized by the term “measured system.” This term, which appears in the recommendations from two of the individual workshops, indicates that multiple options are available for ensuring that pavement markings possess adequate retroreflectivity to meet the needs of road users.
- ! None of the participants could recall an example of a transportation agency being sued over the retroreflectivity of pavement markings. Establishing minimum standards or guidelines will significantly increase the potential for such lawsuits, even when an agency is doing a good job of providing retroreflective pavement markings. Even if the agency is able to successfully defend such lawsuits, the defense of lawsuits is a time- and resource-consuming effort that limits an agency’s ability to fulfill its primary mission to provide a safe and efficient transportation system. Concern over lawsuits is probably the biggest obstacle for gaining acceptance of the concept of minimum retroreflectivity values. For the concept to gain support of public transportation agencies, the guidelines need to be worded so that the potential for lawsuits is minimized.
- ! Participants were concerned that a single retroreflectivity reading could be used in the courtroom to show that an agency did not comply with the minimum retroreflectivity requirements. All participants felt that any minimum retroreflectivity guidelines should include sampling guidelines that require multiple measurements to establish compliance or non-compliance with the guidelines.
- ! The nighttime demonstrations represented a variety of roadway, marking, and viewing conditions. In the dynamic observations, observers were only observing and were not responsible for driving the vehicle. In some cases, observers were also focusing upon very short sections of markings and looking at the marking when it was anywhere from 20 to 200 feet in front of the vehicle. In static observations, participants were able to focus upon a marking 100 feet in front of the vehicle. In the authors’ opinions, neither type of demonstration provided an accurate means of determining how much retroreflectivity is needed by drivers. However, the demonstrations did provide a means of allowing participants, many of whom had never measured pavement marking retroreflectivity, with the ability to relate quantitative retroreflectivity measurements to a visual observation.
- ! As a overall group, the participants did not feel that the FHWA had developed adequate justification for the minimum retroreflectivity values recommended in the draft FHWA research report (2). In particular, the participants felt that more information is needed about the following issues. More detail about many of these issues is provided in the Future Research section of this chapter.
  - ▶ The relationship between pavement marking retroreflectivity and safety.
  - ▶ The impact of retroreflective raised pavement marker condition/performance on the minimum values.
  - ▶ The ability to reduce the minimum values if other types of devices (such as roadway lighting or delineation) are present on a roadway.

- ! The agencies represented by the participants utilize a wide range of pavement surface types. The participants felt that the retroreflectivity of a typical marking will vary according to the pavement surface type. Agencies that use chip seal and slurry seal types of rough pavement surfaces are concerned that a high quality pavement marking on these surfaces will not provide adequate retroreflectivity.
- ! Almost all of the city and county agency participants indicated that they did not measure the retroreflectivity of their markings, but relied upon visual inspections to ensure adequate retroreflectivity. The creation of numerically based minimums would require these agencies to adopt measurement procedures which be extremely burdensome given their limited resources.
- ! The FHWA recently revised the MUTCD to establish warrants for centerline and edge line markings. The workshops were held before this final rule was issued and workshop participants were concerned that the requirements for markings, combined with requirements for marking retroreflectivity, would have a double impact on agencies. Not only would agencies be required to put markings on more roadways, those markings would have minimum retroreflectivity levels associated with them.
- ! Many participants, especially at the local level, indicated that establishing minimum levels of marking retroreflectivity may cause them to reduce the use of pavement markings in their jurisdictions in order to reduce the burdens associated with compliance.
- ! Several participants expressed a concern over how the minimum retroreflectivity guidelines would apply to roads where an agency is abandoning the markings. They wanted to know whether an agency would have to physically remove the marking or would the marking be exempt from the guidelines and be allowed to fade with time.
- ! Currently, there is no national specification or procedure for measuring the retroreflectivity of existing markings (such as an ASTM specification). If minimum levels of pavement marking retroreflectivity are to be established, then a specification should be developed and included in the MUTCD or other national document.
- ! There was significant differences of opinions between the workshops and within individual workshops on which speed category to use for 55 mph roads. Many felt that these roads should be included in the highest speed category as they represent high-speed highways. Others, particularly the local agency representatives, stated that they had many roads with 55 mph speed limits that were not equivalent to high-speed highways and should not be subjected to the same retroreflectivity requirements as highways.

## **WORKSHOP RECOMMENDATIONS**

Based solely on the information received from the three workshops, the workshop facilitators offer the following recommendations related to the minimum values, MUTCD language, proposed rulemaking, and future research. It should be noted that the facilitators, as individuals, may have different views than those recommended below. These recommendations are the facilitators interpretations of the recommendations from the workshops.

### **Recommended Minimum Values and MUTCD Language**

Based solely on the input received from the workshop participants, the workshop facilitators recommend the minimum pavement marking retroreflectivity values shown in Table 15 (speed

based) or Table 16 (classification based). These are for roadways without additional or supplemental visibility assistance (retroreflective raised pavement markers, roadway lighting, etc.). These values form the core for the recommended MUTCD language for implementing minimum levels of in-service retroreflectivity for pavement markings. Appendix F presents the facilitators' recommended language for the MUTCD section that establishes minimum levels of in-service retroreflectivity for pavement markings. The recommended language is based upon the input received from the participants during the workshops.

**Table 15. Speed-Based Minimum Values for Pavement Marking Retroreflectivity**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	≤ 30 mph	35-50 mph	≥55 mph
White	Presence <sup>3</sup>	80	100
Yellow	Presence	65	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

**Table 16. Classification-Based Minimum Values for Pavement Marking Retroreflectivity**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Class of Roadway		
	Local and Minor Collector	Major Collector and Arterial	Highways, Freeways and all roads ≥55 mph
White	Presence <sup>2</sup>	80	100
Yellow	Presence	65	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

As indicated in the table notes, the retroreflectivity values are measured at the 30 meter geometry. As can also be seen in this table, the yellow marking values are about 80 percent of the white values. This is in contrast to the yellow/white ratio of 65 percent contained in the draft FHWA research report.

In developing the values shown in the table, the facilitators considered many different factors that were raised during the workshops. These are described below.

### *Factors Considered for the 0-30 mph Category (Local and Minor Collector roads)*

- ! For this category of roads, only a presence line is required. A presence line is a marking that can be distinguished from the pavement surface, but which has no retroreflectivity value associated with it.
- ! These are low-speed roadways and most are also low-volume. In most cases, they are residential and local streets.
- ! At speeds of 30 mph and less, the illumination provided by vehicle headlights is adequate to meet the visibility needs of most drivers. If the marking has adequate contrast with the pavement surface, retroreflectivity is not needed to provide visibility.
- ! These make up a significant proportion of the roads in local jurisdictions. Establishing a minimum retroreflectivity value for these roads would create greater opposition to minimum retroreflectivity levels among the local agencies.

### *Factors Considered for the 35-50 mph Category (Major Collector and Arterial)*

- ! This category of roads represent arterial and roadways that carry significant volumes of traffic.
- ! The workshop recommendations for minimum values in this category ranged from 65 to 85 for white and 45 to 60 for yellow.

### *Factors Considered for the 55 mph and over Category (Highways and Freeways)*

- ! These are the high speed roadways with the greatest delineation and safety needs.
- ! Includes highways on state roadway network, major expressways/arterial in urban areas, and rural roadways in city and county jurisdictions.
- ! Rural high-speed highways have greater delineation needs. Dark environment, no visual cues to roadway alignment beyond effective headlight range except for pavement markings and delineation.
- ! Some suggestions that freeways should be segregated from rural highways. Accident rates are higher for rural, two-lane highways than on freeways. Rural, non-freeway roadways can have speed limits ranging from 55 to 70 mph. These factors indicate that roadway delineation (pavement marking) should be in the highest category of minimum retroreflectivity values.
- ! The 55 mph speed limit is included in this category due to the fact that many highways in urban areas have 55 mph speed limits. It is also included in the high speed category because it represented the maximum highway speed between 1973 and 1995.
- ! Values of 100 for white and 80 for yellow were considered appropriate minimums for this category by the participants in all of the workshops.

### **Recommendations for Rulemaking**

- ! The *Federal Register* Notice of Proposed Amendments should include the proposed text that would be added to the MUTCD. Recommendations for the MUTCD text is contained in Appendix F.
- ! In the draft research guidelines, there are no recommendations for what constitutes a minimum use of retroreflective raised pavement markers. Information is needed on:

- ▶ Minimum retroreflectivity for retroreflective raised pavement markers.
  - ▶ Spacing between retroreflective raised pavement markers.
  - ▶ Number of retroreflective raised pavement markers that are allowed to be missing.
- ! There were comments made regarding the reduction of minimum values if there were other devices supplementing pavement markings. Devices which were mentioned as potential supplemental devices include retroreflective raised pavement markers, roadway lighting, and delineators. The facilitators recommend that only retroreflective raised pavement markers or roadway lighting be considered as criteria for reducing the minimum values for pavement marking retroreflectivity. For both of these, specific levels of retroreflective raised pavement markers performance or roadway lighting illumination should be established in order for the reduction in minimum retroreflectivity to apply.
- ! A reduction for retroreflective raised pavement markers should be applied only to those lines that are supplemented by the retroreflective raised pavement markers. For example, if the centerline uses retroreflective raised pavement markers, but the lane lines do not, the lane line markings must meet the higher minimum retroreflectivity values. A reduction could not be applied to the lane lines if there are not retroreflective raised pavement markers supplementing the lane lines.
- ! Delineators should not be considered as factors which allow the minimum values to be reduced because, although they help to indicate roadway alignment, they do not provide guidance to help the driver position the vehicle on the roadway..
- ! Minimum retroreflectivity values should be applied to longitudinal (long) lines only.
- ! There were numerous comments that the minimum values may actually discourage agencies from providing markings on roadways where they are not required or recommended (see Appendix B for the new MUTCD warrants for centerlines and edge lines). Therefore, the minimum retroreflectivity values are intended to apply only to those markings that are required or recommended by the MUTCD.

## **Recommendations for Future Research**

The workshop participants identified several issues for which more information should be provided prior to or as part of the rulemaking process. These issues include:

- ! Retroreflective raised pavement markers (retroreflective raised pavement markers).
- ! Roadway lighting.
- ! Relationship between pavement marking retroreflectivity and safety.

### *Retroreflective Raised Pavement Markers*

The FHWA draft report on minimum levels of pavement marking retroreflectivity (2) allow significantly lower levels of pavement marking retroreflectivity if retroreflective raised pavement markers (retroreflective raised pavement markers) are present. However, there is no quantitative relationship between the minimum levels of pavement marking retroreflectivity and the retroreflective performance of the retroreflective raised pavement markers. The research related to lowering the minimum levels of retroreflectivity if retroreflective raised pavement markers are used (9) indicates that the retroreflective raised pavement markers should be “*in good working*



order” and spaced at 80 foot intervals. There is no data that establishes a minimum performance level for the pavement markings. Experience has shown that the retroreflectivity of retroreflective raised pavement markers decrease over time. Retroreflective raised pavement markers are typically spaced at 40 or 80 feet on the highway. Furthermore, as a point source, retroreflective raised pavement markers can be removed or destroyed on the pavement surface by vehicular traffic, snowplows, or other causes. If several adjacent retroreflective raised pavement markers are removed or destroyed, then a driver may not have guidance from retroreflective raised pavement markers for a distance of up to several hundred feet. If there will be minimum retroreflectivity guidelines for pavement markings, and if those minimums can be lowered if retroreflective raised pavement markers are present, and if there are variables in the performance of retroreflective raised pavement markers, then it stands to reason that there should also be minimum performance requirements associated with retroreflective raised pavement markers. These minimums should address: retroreflectivity, spacing, accommodation of missing retroreflective raised pavement markers, and the application of a potential reduction to lines that are not supplemented by retroreflective raised pavement markers when other lines on the roadway are. The FHWA should conduct additional research to determine how retroreflective raised pavement markers should be accommodated within the minimum pavement marking retroreflectivity guidelines.

### *Roadway Lighting*

As mentioned, the draft minimum values recommended by the FHWA research indicate that the minimum levels can be reduced if retroreflective raised pavement markers are present. The participants indicated that such a reduction should also be applied when roadway lighting is sufficient to provide adequate visibility of pavement markings without assistance from retroreflective performance. This reduction of the minimum values is especially important to many local agencies that tend to use roadway lighting on urban roadways. If roadway lighting is to be considered as a criteria for applying reductions to the minimum values, the FHWA needs to establish the minimum lighting levels that must exist for the reduction to apply. This may require additional research, but it is likely that the information already exists and only needs to be applied to the process.

### *Safety Benefits of Retroreflective Pavement Markings*

The relationship between pavement markings and safety has been evaluated in many different studies. In general, these studies have found a strong benefit to providing effective pavement markings and delineation to road users. However, there has been little research that directly relates the retroreflectivity of markings to safety.

For several years, the FHWA has been sponsoring a research study on all-weather pavement markings (10). One part of that study involves a safety evaluation of all-weather pavement markings. The findings indicate that all-weather pavement markings resulted in a statistically significant decrease in dry-weather nighttime crash frequency. The magnitude of the decrease was about 11 percent. However, no effect was found for wet-weather nighttime crash frequency. In fact, the data indicate that crash frequency increased by 15 percent, but the increase was not statistically significant. The safety evaluation summarized that all-weather pavement marking

installation suggest an overall positive safety effect, but the observed effect is not statically significant.

The workshop participants repeatedly asked for information regarding the safety benefits of improving pavement marking retroreflectivity. Many participants indicated that they could not support a significant increase in agency spending on improving pavement marking retroreflectivity unless there was research or other quantifiable findings that indicate a safety benefit of higher retroreflectivity. These participants stated that they would rather devote their limited resources to improvements that they knew would have a safety benefit rather than improved retroreflectivity which does not have a proven safety benefit. It should be noted that at the time of the workshops, the draft of the all-weather pavement marking report was not available.

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## CHAPTER 6

# REFERENCES

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1. Manual on Uniform Traffic Control Devices for Streets and Highways. U.S. Department of Transportation, Washington, D.C., 1988.
2. Turner, J. Dan. Pavement Marking Retroreflectivity: Research Overview and Recommendations. Office of Safety and Traffic Operations Research and Development, Federal Highway Administration, McLean, Virginia, December 2, 1998, Unpublished Draft Report.
3. Fontaine, M.D. and H.G. Hawkins, Jr. Evaluation Findings of the Mirolux Plus 30 Pavement Marking Retroreflectometer, Report #40465, Highway Innovative Technology Evaluation Center, Washington, D.C., January 2000.
4. Fontaine, M.D. and H.G. Hawkins, Jr. Evaluation Findings of the Laserlux Mobile Pavement Marking Retroreflectometer, Report #40466, Highway Innovative Technology Evaluation Center, Washington, D.C., January 2000.
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6. Fontaine, M.D. and H.G. Hawkins, Jr. Evaluation Findings of the FRT01 Pavement Marking Retroreflectometer, Report #40468, Highway Innovative Technology Evaluation Center, Washington, D.C., January 2000.
7. Fontaine, M.D. and H.G. Hawkins, Jr. Evaluation Findings of the LTL 2000 Pavement Marking Retroreflectometer, Report #40469, Highway Innovative Technology Evaluation Center, Washington, D.C., January 2000.
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9. Zwahlen, H.T. and T. Schnell. Pavement Marking Visibility Research and Proposed Values for Minimum Required Pavement Marking Retroreflectivity, Federal Highway Administration, Washington, D.C., August 1998 Unpublished Draft Report.
10. Migletz, J., J.L. Graham, D.W. Harwood, K.M. Bauer, and P.L. Sterner. Evaluation of All-Weather Pavement Markings. Federal Highway Administration, Washington, D.C., February 2000, Unpublished Draft Report.



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**APPENDIX A**  
**RETROREFLECTIVITY ADVANCE NOTICE**

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The following pages present the text of the April 26, 1985 *Federal Register* advance notice of proposed amendments to the MUTCD regarding adding standards to the MUTCD for minimum in-service retroreflective performance of traffic control devices.

**DEPARTMENT OF TRANSPORTATION**

**Federal Highway Administration  
23 CFR Parts 625 and 655**

**[FHWA Docket No. 85-18]**

**National Standards for Traffic Control Devices, Manual an Uniform Traffic Control Devices; Standards for Performance of Retroreflective Traffic Control Devices; Request for Comments**

**AGENCY:** Federal Highway Administration (FHWA), DOT.

**ACTION:** Advance notice of proposed amendments to the manual on uniform traffijc control devices: request for comments.

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**SUMMARY:** The FHWA is inviting comments on a petition from the Center for Auto Safety (CAS) to initiate rulemaking consideration on the issue of standards for retroreflective illumination of traffic control devices. If adopted, these standards could be incorporated into the Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD is incorporated by reference in the design standards for Federal-aid highways found in Part 825 of Title 23, Code of Federal Regulations (CFR). It is also recognized in 23 CFR Part 655 as the national standard for traffic control devices on all public roads.

**DATE:** Comments must be received on or before February 15,1986.

**ADDRESS:** Submit written comments, preferably in triplicate, to FHWA Docket No. RS-18, Federal Highway Administration, Room 4205, HHC-10, 400 Seventh Street SW., Washington, D.C. 205'90. All comments received will be available for examination at the above address between 7:45 a.m. and 4:15 p.m. e.t., Monday through Friday. those desiring notification of receipt of comments must include a self-addressed, stamped postcard. The MUTCD is available for inspection and copying as prescribed in 49 CFR Part 7, Appendix D. It may be purchased for \$30-00 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 050-001-81001-8.

**FOR FURTHER INFORMATION CONTACT:** Mr. Philip O. Russell, Office of Traffic Operations, (202) 426-0411, or Mr. Michael J. Laska, Office of the Chief Counsel, 426-0762, 400 Seventh Street SW., Washington, D.C. 20590. Office hours are from 7:45 a.m. to 4:15 p.m. e.t.. Monday through Friday.

**SUPPLEMENTARY INFORMATION:** The FHWA both receives and initiates requests for amendments to the MUTCD. The MUTCD presents traffic control device (TCD) standards for all streets and highways open to public travel regardless of type or class or the governmental agency, having jurisdiction.

The MUTCD fulfills a statutory responsibility imposed on the Secretary of Transportation in sections 109(b), 109(d), and 402(a) of Title 23 of the U.S.C. and delegated to the Federal Highway Administrator in 49 CFR 1.48 (b), (c), and (n). Generally, 23 U.S.C. 109 authorizes the Secretary to develop approve, and apply standards for the construction of highways in which

Federal funds participate. Section 109(b) calls for standards for the Interstate System to be applied "uniformly throughout the States." Section 109(d) directs the secretary to approve only such standards for "the location, form, and character" of signs, signals, and markings on Federal-aid highways "as will promote the safe and efficient utilization of the highways." Section 402(a) authorizes to Secretary to promulgate uniform national standards relating to "highway design and maintenance (including lighting, markings, and surface treatment), traffic control, vehicle codes and laws, surveillance of traffic," etc., for use on all public roads.

This advance notice is being issued so that interested persons and/or organizations may have the opportunity to participate in the consideration of this request for amendments to the MUTCD. Based upon comments received in response to this advance notice and upon its own experience, the FHWA may prepare a notice of proposed amendments. Any final amendments which result from that action will be published in the Federal Register and incorporated by reference in the Code of Federal Regulation.

The basic requirements for highway signs and pavement markings are that they be legible and understood in time to permit a proper response. This means high visibility lettering or symbols of adequate size, and a short, accurate legend for driver comprehension at highway speed. Standard colors and shapes are specified so that special classes of traffic signs can be promptly recognized. Simplicity and uniformity in color, shape, position, and application are stressed throughout the MUTCD. The MUTCD presently provides that: (a) Regulatory and warning signs, unless excepted in the standards covering a particular sign or group of signs, shall be retroreflectorized or illuminated to show the same shape and color both by day and night, (b) pavement markings, which must be visible at night, shall be retroreflectorized unless ambient illumination assures adequate visibility, and (c) all pavement markings on Interstate highways shall be retroreflectorized.

The MUTCD contains no minimum initial or maintained retroreflective requirements for retroreflective signs, pavement markings, or traffic control devices. Minimum initial retroreflective requirements for new sheeting materials do exist. They are contained in General Services Administration's (GSA) Federal Specifications L-S-300C<sup>1</sup> and in "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-79"<sup>2</sup> (FP-79) U.S. DOT FHWA. The FP-79 is issued primarily for use in the construction of roads and bridges on Federal highway projects under the direct supervision of the FHWA. The State and local highway agencies have direct supervision of their respective systems including the Federal-aid highway systems and, therefore, are not bound by the FP-79. Many State and local highway agencies have elected to use either the GSA or the, FP-79 specification for procurement of sign sheeting material. The FP-79 also contains minimum maintained retroreflective intensity specifications for sheeting materials in construction and maintenance zones. The FHWA is not aware of any State or highway agency that has adopted these standards.

The CAS petition acknowledges that the MUTCD sets forth standards for size, shape, and color as well as legend size and spacing for traffic control devices. However, the petition contends that the range of legally licensable drivers is not accommodated by the traffic control devices allowed in the MUTCD with respect to nighttime conspicuity dependent upon retroreflective illumination. Copies of the CAS petition will be distributed to everyone currently

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<sup>1</sup>This document is available for inspection and copying at the Federal Highway Administration, Office of Traffic Operations, HTO-21, Room 3419, 400 7th Street SW, Washington, D.C. 20510.

<sup>2</sup>This document is available for inspection and copying at the Federal Highway Administration, Office of Traffic Operations, HTO-21, Room 3419, 400 7th Street SW, Washington, D.C. 20510.

appearing on the FHWA mailing list for MUTCD matters. Those wishing to be added to the mailing list or receive a copy of the petition should write to FHWA, Office of Traffic Operations, HTO-21, 400 Seventh Street SW., Washington, D.C. 20590.

### **Discussion of Problem**

In the mid-1970's, approximately 55 percent of all vehicle deaths were reported to have occurred during the hours of darkness. By the early 1980's, the proportion of fatalities occurring at night had increased steadily to about 60 percent. Given the facts that hours of darkness constitute only about 40 percent of a 24-hour day and only about 25 percent of all travel occurs during this same period, nighttime accidents are over-represented in accident statistics. The night fatality rate is more than three times that of the daytime rate. The rural driver has a significantly greater nighttime risk than the driver in urban areas when compared on the basis of relative exposure (per vehicle miles of travel). Approximately two-thirds of nighttime fatalities occur on unlighted roadways mainly in rural areas. The proportion of single vehicle fatalities occurring at night has increased from 62 to 68 percent between 1975 and 1982.

It is generally recognized that a single causal factor cannot be assigned to night accidents. A driver's night vision characteristics and a lack of adequate visual guidance information are significant factors in the greater accident and fatality rates at night. Fatigue, intoxication, inclement weather, higher speeds of travels on some roadways, and other factors all contribute to the hazards of night driving. For example, accident risks are considerably greater on wet pavements at night than on dry pavements. The problem is even more extreme for operation on wet roads with control of access. The risk of an accident under night, wet conditions on a freeway appears to be about 10 to 15 times greater than that during dry, daytime conditions.

All of the above mentioned factors are made worse by poor visibility. The great majority of information that the road user requires to effectively carry out driving in an efficient manner is obtained through the visual senses. The driver at night is presented with an extremely difficult task in a moving vehicle where the luminance level of the background scene and on the roadway itself often shifts very rapidly. The driver's light/dark adaptation must change quickly and continually as the light level is changed. The ability to detect and recognize objects falls off rapidly as the light level decreases to the level typical of night driving. Glare from oncoming vehicles and adjacent roadside developments present problems. Visual acuity, contrast sensitivity, distance judgment, speed of seeing, and color discrimination are all impaired by the relative darkness of the night driving environment. Therefore, anything done to enhance night visibility is likely to improve driver performance.

In addition to lighting, the primary techniques used to ameliorate the night visibility problem has been through the retroreflective treatment of signs, pavement markings, and delineators, and improved vehicular headlamp systems. Prior to 1980, there had been considerable research involving those techniques in simple, uniform backgrounds, aimed at improving legibility of signs and the detection distance at which objects are seen along the highway. For many roadway situations, particularly on low volume, rural roads, these studies showed vehicular headlamp illumination with limited pavement markings (i.e., center lines) and signing was sufficient to provide the driver with the needed guidance information. However, as the roadway environment becomes more complex, vehicular headlamps and deteriorating traffic control devices cannot provide the information needed for efficiently carrying out the driving task.

Laboratory studies suggest that only a modest level of illumination, far lower than daylight, is required to provide the necessary conditions for effective performance in almost any night driving environment. The difficulty of the driver's task and, therefore, the quality of visual



information needed, is largely dependent upon the complexity of inputs presented to the visual senses. Visual complexity is determined by road geometry, maneuvering of other traffic, adjacent land uses, advertising signs, pedestrian activity, weather, traffic control devices, lighting, and maintenance of road features, and many other factors. Also important is the degree of driver impairment by such factors as alcohol and drugs, age, vision problems, and fatigue.

At the present time the FHWA's research plans which address these subjects are based on the recognition that the most pressing research need is to develop an understanding of how operational complexity of the driving environment affects the various techniques being used to provide visual guidance information to the driver and how these techniques interact. This research builds on past knowledge to determine what techniques and equipment should be used in which specific situations and how often and by what methods traffic control devices should be refurbished or replaced.

Even upon the completion of the above research, the FHWA recognizes that a significant gap will exist between the new information (research results) and the successful adoption of acceptable minimum maintained retroreflection standards for traffic control devices. Therefore, the FHWA has decided to open a public docket to receive information concerning the practicality of developing retroreflection standards for traffic control devices as well as research and measuring methods/devices which would be needed to determine and to objectively measure retroreflection standards.

The FHWA has formulated the following questions and invites responses concerning the retroreflective performance of traffic control devices during periods of reduced visibility:

1. Are standards needed for minimum maintained retroreflective performance requirements for traffic control devices (traffic signs, barricades, pavement markings, delineators, hazard markers, etc.) including those devices used in work zones? Are maximum initial and maintained retroreflective performance requirements needed for any specific colors or applications?

2. Should standards be based on retroreflectivity measurements or on minimum distances at which traffic control devices need to be visible and comprehensible to a motorist under a wide range of driving environments and conditions?

3. Have any highway agencies established retroreflective performance standards for their traffic control devices? If so, what are the basis of the performance standards? How long have they been in use and are they adequate? What problems have developed through their use? How cost-effective are they? Are these existing practices or procedures being used by highway agencies to determine when traffic control devices need to be replaced or refurbished?

4. In establishing minimum maintained retroreflective requirements for traffic control devices, are there special needs to be considered such as the "design driver", driver information processing, aging motorists, glare sensitivity, vehicle characteristics (i.e., head lights, windshields, eye height), complex visual backgrounds, high information load, and weather? Should a table be developed similar to Table II-1 "A Guide for Advance Warning Sign Placement Distance" as shown on page 2c-2a of the MUTCD?

5. Should there be retroreflection uniformity within a single sign or of signs within a single display or should certain signs have higher retroreflection than other signs for example, Stop signs as compared to Do Not Litter signs)? Are there available data or research results for classifying (in order of sign of importance) traffic sign retroreflection needs?

6. Should traffic control devices retroreflective requirements be indicated in Specific Intensity per unit Area (SIA)<sup>3</sup>, Coefficient of Luminous Intensity (CIL) per unit area<sup>4</sup>, luminance<sup>5</sup>, or other units?

7. What instruments and procedures for measuring retroreflection of traffic control devices should be specified, are being used, or are available for use? If instruments or procedures have been used, were they practical and satisfactory?

8. What research studies are needed to develop reasonable performance standards?

9. What research studies are needed to develop performance measuring instruments?

10. Would comprehensive standards be cost-effective? Why or why not?

This advance notice of proposed rulemaking to the MUTCD is issued under the authority of 23 U.S.C. 109(d), 315, and 402(a), and the delegation of authority in 49 CFR 1.48(b).

It is anticipated that any proposed changes to the MUTCD resulting from the comments received would be included in a subsequent Notice of Proposed Rulemaking.

The FHWA had determined, at this time, that this document contains neither a major rule under Executive Order 12291 nor a significant proposal under the regulatory policies and procedures of the Department of Transportation. This determination will be reevaluated and a draft regulatory evaluation will be prepared, if necessary based upon the data received in response to this advance notice. Based upon the information available to the FHWA at this time, the action proposed in this advance notice will not have a significant economic impact on a substantial number of small entities.

**List of Subjects in 23 CFR Parts 625 and 655**

Design standards, Grant programs-transportation, Highways and Roads, Signs, Traffic regulations, Incorporation by reference.

(Catalog of Federal Domestic Assistance Program Number 20.205, Highway Research, Planning and Construction. The regulations implementing Executive Order 12372 regarding intergovernmental consultation on federal programs and activities apply to this program)

Issued on: April 22, 1985.

R.A. Barnhart,

Federal Highway Administrator, Federal Highway Administration.

[FR Doc. 85-10178 Filed 4-25-85, 8:45 am]

BILLING CODE 4910-22-M

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<sup>3</sup>SIA: Candelas per footcandle per square foot.

<sup>4</sup>CIL per unit area: Candelas per lux per square metre (Metric equivalent of SIA).

<sup>5</sup>Luminance: Foot-laberts (English), Candelas per square metre (Metric).

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## APPENDIX B

# CENTERLINE AND EDGE LINE FINAL RULE

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The following pages present the text of the January 3, 2000 *Federal Register* final rule revising the MUTCD to include standards for centerline and edge line markings. It should be noted that this final rule had not been issued at the time of the workshops. Figure 6 presents the MUTCD text as proposed in the August 2, 1996 *Federal Register* notice. This is the proposed language that was distributed to the workshop participants during the workshop.

The FHWA proposes replacing the fifth paragraph of Section 3B-1 of the 1988 version of the MUTCD with the following:

Center line markings shall be placed on paved, undivided 2-way streets and highways having the characteristics as follows:

1. Rural arterials and collectors with roadways 18 feet or more in width and an average daily traffic (ADT) of 1000 or more.
2. Urban arterials and collectors with roadways 20 feet or more in width and an ADT of 2000 or more.
3. Roadways with 3 lanes or more.

Center line markings should be placed on paved, undivided 2-way streets and highways having the following characteristics:

1. Rural roadways 18 feet or more in width with an ADT of 500 or more.
2. Urban roadways 20 feet or more in width with an ADT of 1000 or more.
3. Roadways where engineering studies indicate a need.

Center line markings may be placed on any undivided 2-way streets and highways.

In determining whether to place centerline markings on roadways less than 16 feet wide, the risk of vehicles on pavement edges or of drivers being adversely affected by parked vehicles may be considered. Also when edge line markings are used the risk of persistent vehicle encroachment into the lane of opposing traffic may be considered.

The FHWA proposes replacing the second paragraph of Section 3B-6 with the following:

Edge line markings shall be white except that on the left edge of each roadway of divided streets and highways, and 1-way roadways in the direction of travel, they shall be yellow.

Edge line markings shall be placed on paved streets and highways of the following types or with the following characteristics, except when roadway edges are defined by curbs and/or by markings for parking spaces:

1. Freeways,
2. Expressways, and
3. Rural arterials.

Edge line markings should be placed on paved streets and highways with the following characteristics, except when roadway edges are defined by curbs and/or by markings for parking spaces:

1. Rural collectors 20 feet or more in width,
2. Paved streets and highways where an engineering study indicates a need.

Edge line markings may be placed on other classes of streets and highways with or without center line markings.

**Figure 6. Original Proposed Language for Centerlines and Edge Lines**

[Federal Register: January 3, 2000 (Volume 65, Number 1)]  
[Rules and Regulations]  
[Page 9-14]  
From the Federal Register Online via GPO Access [wais.access.gpo.gov]  
[DOCID:fr03ja00-4]

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## **DEPARTMENT OF TRANSPORTATION**

### **Federal Highway Administration**

23 CFR Part 655

[FHWA Docket Nos. 97-2295 (96-47), 97-2335 (96-15), and 97-3032]  
RIN 2125-AD68

National Standards for Traffic Control Devices; the Manual on Uniform Traffic Control Devices for Streets and Highways; Standards for Center Line and Edge Line Markings

**AGENCY:** Federal Highway Administration (FHWA), DOT.

**ACTION:** Final amendments to the Manual on Uniform Traffic Control Devices (MUTCD).

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**SUMMARY:** This document contains amendments to the MUTCD as adopted by the FHWA. The MUTCD is incorporated by reference in 23 CFR part 655, subpart F and recognized as the national standard for traffic control devices on all public roads.

The amendments herein change various sections of Part 3, Markings, of the MUTCD. The FHWA is adopting the amendments pursuant to section 406 of the Department of Transportation and Related Agencies Appropriations Act, FY 1993, which requires that the MUTCD include a national standard to define the roads that must have center line or edge line markings or both, provided that in setting such a standard, consideration be given to the functional classification of roads, traffic volumes, and the number and width of lanes. The FHWA has also received requests to include such standards in the MUTCD for center line or edge line markings. The MUTCD amendments contain the requirements and recommendations for the uniform application and use of center line and edge line markings on streets and highways. The amendments are intended to improve traffic operations and safety through consistent and uniform use of such markings.

**DATES:** The final rule is effective January 3, 2000. Incorporation by reference of the publication listed in the regulations is approved by the Director of the Federal Register as of January 3, 2000.

**FOR FURTHER INFORMATION CONTACT:** Mr. Ernest D. L. Huckaby, Office of Transportation Operations, HOTO, (202) 366-9064, or Mr. Raymond W. Cuprill, Office of the Chief Counsel (HCC-20), (202) 366-0834, Department of Transportation, Federal Highway Administration, 400 Seventh Street, SW., Washington, DC 20590. Office hours are from 7:45 a.m. to 4:15 p.m., e.t., Monday through Friday except Federal holidays.

## **SUPPLEMENTARY INFORMATION:**

### **Electronic Access**

Internet users may access all comments received by the U.S. DOT Dockets, Room PL-401, by using the universal resource locator (URL): <http://dms.dot.gov>. It is available 24 hours each day, 365 days each year. Please follow the instructions online for more information and help.

An electronic copy of this document may be downloaded using a modem and suitable communications software from the Government Printing Office's Electronic Bulletin Board Service at (202) 512-1661. Internet users may reach the Office of the Federal Register's home page at: <http://www.nara.gov/fedreg> and the Government Printing Office's database at: <http://www.access.gpo.gov/nara>.

The text for these sections of the MUTCD is available from the FHWA Office of Transportation Operations (HOTO-1) or from the FHWA Home Page at the URL: <http://www.ohs.fhwa.dot.gov/devices/mutcd.html>. Please note that the current rewrite sections contained in this docket for MUTCD Part 3 will take approximately 8 weeks from the date of publication before they will be available at this web site.

### **Background**

The 1988 MUTCD is available for inspection and copying as prescribed in 49 CFR part 7. It may be purchased for \$57.00 (Domestic) or \$71.25 (Foreign) from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954, Stock No. 650-001-00001-0. The purchase of the MUTCD includes the 1993 revision of Part 6, Standards and Guides for Traffic Controls for Street and Highway Construction, Maintenance, Utility and Incident Management Operation, dated September 1993.

The FHWA both receives and initiates requests for amendments to the MUTCD. Each request is assigned an identification number which indicates by Roman numeral, the organizational part of the MUTCD affected, and by Arabic numeral, the order in which the request was received. The MUTCD request identification number for the amendments promulgated by this final rule is MUTCD Request III-73 (Change), titled "Standards for Center Line and Edge Line Markings." The text changes will be published in the next edition of the MUTCD.

The FHWA is promulgating this final rule in response to MUTCD Request III-73 (Change) as addressed in the proposed rules in Docket Nos. 96-15 and 96-47, to MUTCD Request III-35 (Change) as addressed in Docket No. 87-21, and to section 406 of the Department of Transportation and Related Agencies Appropriations Act, FY 1993 (Pub. L. 102-388, 106 stat. 1520, at 1564). The FHWA rearranged its docket system to accord with the electronic system adopted by the Department of Transportation in 1997. The FHWA Docket Numbers 96-15 and 96-47 were transferred and scanned as FHWA Docket Numbers 97-2335 and 97-2295, respectively. The amendments to the MUTCD and the related actions are contained within this document as well as a discussion summarizing the basis for the amendments.

The FHWA first proposed center line and edge line standards that were published January 27, 1988, at 53 FR 2233 in response to MUTCD Request III-35 (Change). The majority of the commenters believed that the then existing standards did not need to be changed. The FHWA published a decision on January 23, 1989, at 54 FR 2298 that it was not appropriate to set national standards for centerline markings at that time. The decision also stated that the FHWA would consider alternative actions to better determine standards that are responsive to the motorists needs and to the concerns expressed in the docket comments.

This document contains the disposition of proposed standards for the 1988 MUTCD as published on August 2, 1996, at 61 FR 40484. It also discusses the disposition of an alternative proposed standard subsequently published on January 6, 1997, at 62 FR 691 as part of the proposed future edition of the MUTCD.

In developing these amendments to the 1988 MUTCD, the FHWA has reviewed the comments received in response to the FHWA dockets and other information related to the MUTCD and the proposals.

### **Definitions**

For the purposes of this standard, the following terms shall be defined by the road jurisdiction in accordance with MUTCD Section 1A-9, Definitions of Words and Phrases. The FHWA is considering, through a series of proposed rules, the addition of such terms and definitions in a future edition of the MUTCD. The proposed definitions of “arterial highway,” “collector highway,” and “traveled way” were contained in a proposed rule published at 62 FR 64324 on December 5, 1997, in FHWA Docket 97-3032. The other terms may be included in future proposed rulemaking for the future edition of the MUTCD based on need and public requests.

The following definitions should be used for the terms contained in the proposed rule and this final rule:

Roadway shall mean that portion of a highway improved, designed or ordinarily used for vehicular travel, exclusive of the sidewalk, berm or shoulder even though such sidewalk, berm or shoulder is used by persons riding bicycles or other human powered vehicles. In the event a highway includes two or more separate roadways, the term “roadway” as used herein shall refer to any such “roadway” separately but not to all such roadways collectively. Roadway includes parking lanes.

Traveled way shall mean that portion of the roadway excluding the parking lanes.

Collector highway shall mean a general term denoting a highway which in rural areas connects small towns and local highways to arterial highways, and in urban areas provides land access and traffic circulation within residential, commercial and business areas and connects local highways to the arterial highways. This highway may be designated as part of a collector highway system.

Arterial highway shall mean a general term denoting a highway primarily used by through traffic, usually on a continuous route or a highway designated as part of an arterial highway system.

### **Amendments to the MUTCD**

The FHWA replaces the fifth paragraph of section 3B-1 of the 1988 version of the MUTCD with the following:

Center line markings shall be placed on paved, 2-way traveled ways on streets and highways having one or more of the following characteristics:

1. Urban and rural arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.
2. Urban and rural traveled ways with 3 lanes or greater.

Center line markings should be placed on paved, 2-way traveled ways on streets and highways having the following characteristics:

1. Urban arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 4000 or greater.
2. Rural arterials and collectors with traveled ways 5.4 meters (18 feet) or more in width with an ADT of 3000 or greater.

Center line markings may be placed on other 2-way traveled ways on any street and highway.

On traveled ways less than 4.8 meters (16 feet) wide, an engineering study should be used in determining whether to place center line markings on traveled ways due to traffic encroaching on the pavement edges, due to traffic being affected by parked vehicles, and due to traffic encroachment into the lane of opposing traffic where edge line markings are used.

The FHWA replaces the second paragraph of section 3B-6 of the 1988 version of the MUTCD with the following:

Edge line markings shall be white, except they shall be yellow for the left edge in the direction of travel of the traveled ways of a divided or one way street or highway.

Edge line markings shall be placed for paved traveled ways on streets and highways with the following characteristics:

1. Freeways,
2. Expressways, and
3. Rural arterials with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.

Edge line markings should be placed on paved travel ways for streets and highways with the following characteristics:

1. Rural collectors with traveled ways 6 meters (20 feet) or more in width.
2. Other paved streets and highways where engineering study indicates a need.

Edge line markings may be placed on the traveled way on any other street or highway with or without center line markings.

Edge line markings may be excluded based on engineering judgment where the travel way edges are delineated by curbs or other markings.

### **Compliance Date**

Since the changed standards and guidelines for lane markings may impose some additional costs to State and local jurisdictions, the FHWA is establishing a compliance date for the installation of new markings. The compliance date is 3 years after the effective date of this final rule or when pavement lane markings are replaced within an established pavement marking program, or when the highway is resurfaced or reconstructed, whichever date is earlier. This will allow the replacement of the pavement lane markings after the normal service life of the markings.

### **Discussion of Amendment**

The FHWA believes that these new standards will effectively and practically enhance highway safety and traffic operations by requiring and recommending the minimum use of center line and edge line markings throughout the nation for specific classes of streets and highways as defined by the standards. The typical road user's expectancies can be met through a nationally uniform and consistent application of these markings for warning, guidance, and delineation purposes in accordance with these standards.

The standards require the use of these markings for paved traveled ways of streets and highways with the highest traffic volumes and design standards in the nation. The standards also contain recommendations and information to support nationally uniform placing of markings on other roads.

Based on the information submitted to the FHWA, the FHWA believes that most of the required and recommended markings in accordance with these standards are currently in place. Generally, the markings have been provided by most jurisdictions as a result of good engineering practices, and in some cases, as a result of their own regulations and policies.

The new standards will help assure that all road jurisdictions provide at least the required minimum markings when applicable. This change will require some, mostly local, jurisdictions to provide the markings on some roads for the first time. The FHWA estimates that the additional costs nationwide to meet the new minimum requirements could total approximately \$10 million to \$20 million per year. Additional costs may be incurred at a jurisdiction's discretion if they place markings in accordance with the FHWA recommendations and information for markings. These costs, in most cases, are eligible for Federal or Federal-aid funding.

As discussed in the proposed rule, the FHWA initially proposed standards for which road locations would require a center line in FHWA Docket No. 87-21 in response to MUTCD Request III-35 (Change), "Warrants for Center Line Pavement Markings." The FHWA terminated that docket on January 23, 1989, at 54 FR 2998 without change to the MUTCD and stated that it would consider alternative actions necessary to better determine standards responsive to the motorists' needs and to the concerns expressed in the docket comments. As a result, and pursuant to section 406 of the Department of Transportation and Related Agencies Appropriations Act, FY 1993, and other requests, the FHWA initiated MUTCD Request III-73 (Change), "Standards for Center Line and Edge Line Markings."

In response to this request, the FHWA published in Docket 96-15 on August 2, 1996, at 61 FR 40484, the proposed changes for the 1988 MUTCD.

In general, the public comments received for this docket indicated that the proposed standards would be too extensive in the number of additional roads required to be marked and in the associated costs.

Many commenters for this docket indicated that a proposed standard submitted by the National Committee on Uniform Traffic Control Devices (NCUTCD) and published with the proposed rule would reasonably fulfill the road user needs for markings while economically standardizing the current and proven marking practices of most road jurisdictions.

Subsequently, in Docket No. 96-47 on January 6, 1997, at 62 FR 691, the FHWA published proposed marking standards for a future edition of the MUTCD and included for public comment a different proposed standard that was similar to the proposed standard submitted by the NCUTCD in Docket 96-15. Therefore, in developing this final rule, the FHWA assessed public comments on the two differing proposed standards contained in Dockets 96-15 and 96-47.

An analysis of Docket 96-15 reveals that over half of the comments were opposed to the proposed amendment. In general, the comments stated that the warrants were too restrictive and/or too expensive. A similar analysis of Docket 96-47 reveals that less than ten percent of the comments stated that the warrants were too restrictive and/or too expensive.

This final rule promulgates marking standards that improve the safety of road users, while being responsive to the public comments submitted to the dockets. The proposed amendment was changed by adjusting the values for traveled way width and Average Daily Traffic (ADT) that is responsive to the public comments submitted to the dockets while still enhancing highway safety, traffic operations, and considering the costs to local jurisdictions.

This final rule also fulfills the requirements of section 406 of the Department of Transportation and Related Agencies Appropriations Act, FY 1993. The FHWA considers the number and width of lanes criteria required by section 406 to be satisfied by use of the traveled way width criteria in the standard because of the interrelations of these criteria as contained in road design standards used by most jurisdictions and referenced in the MUTCD.

For the proposed standard published August 2, 1996, in Docket No. 96-15, the 103 commenters submitted responses to the docket including 10 States, 32 counties, 46



municipalities, 6 consultants, 6 local government groups, 2 individuals, and 1 transportation group. Six commenters supported the entire proposed standard. The main issues and concerns discussed by most commenters who opposed the proposed standards included the establishing of required standards in lieu of recommended standards, the potential of additional costs, the need to clearly define the criteria, and the potential traffic and safety impacts. The FHWA believes that the various modifications to the proposed standards in preparing the standards herein adequately address and resolve the majority of commenter objections to the standards. The FHWA also believes that the final rule will enhance safety for highway users.

Many commenters opposed establishing the mandatory requirements within the MUTCD for the markings placement standards and preferred the use of recommendations. The primary reasons included reduction in a road jurisdiction's engineering judgment and their potential increases in liability in determining where limited markings resources should be best applied based on traffic and safety needs. Many were concerned that the requirements did not allow for engineering judgment when safety, traffic and resource considerations may determine the special needs for markings.

The final rule was modified to allow adjustments when an engineering study indicates the markings would cause potential safety hazards. Twenty-six commenters were concerned about the potential liability to the highway jurisdictions if some markings do not continuously meet the proposed new requirements. Another liability concern was the limited available engineering judgment for adjusting resources that may be inadequate to provide for the required as well as additionally critical marking needs.

The FHWA modified the criteria values to reduce the number of roads requiring markings, and to provide for more engineering judgment based on the State and local safety and traffic needs while still improving safety. The FHWA also addressed these concerns by adding a provision which allows engineering studies and engineering judgment to determine the marking requirements for safety issues. The FHWA believes that the minimum national requirements for the markings are needed pursuant to the requirements in section 406 and to help improve the uniform application of the markings on a national basis for the roads which can have the most substantial impacts on safety and traffic operations.

Many commenters were concerned about the potential additional costs, mostly for the local jurisdictions, associated with installing and maintaining the required markings, especially where no or minimal markings are currently in place. Most States currently provide the markings which would be required by the rule, but local jurisdictions vary in compliance. Originally, the FHWA estimated that the proposed requirements could have increased the marking costs nationwide by approximately \$50 million to \$100 million.

Twenty commenters indicated acceptance of the National Committee on Uniform Traffic Control Devices (NCUTCD) proposed standards which would reduce the number of roads requiring the markings and, therefore, reduce the required costs. The FHWA modified the requirements to reflect the NCUTCD criteria and added provisions for increased engineering judgment in marking placement. The FHWA believes that these modifications will still improve the overall safety of the Nation's highways while mitigating the potential increased costs to State and local jurisdictions.

Some commenters were concerned with the cost of surveying the roads to determine where the markings would be required in each jurisdiction. The FHWA believes that jurisdictions should be aware of the ADT's and widths of the major roadways now specified in the standards and that the ADT's are an estimate that can be performed at a jurisdiction's judgment. Based on

the traveled way widths and ADT's in this final rule the estimated costs are significantly reduced. The FHWA now estimates that the additional total cost nationwide to meet the new minimum requirements may total only \$10 million to \$20 million per year. These costs, in most cases, are eligible for Federal or Federal-aid funding at the jurisdictions' judgment and, therefore, these standards would not constitute an unfunded Federal mandate as mentioned by some commenters.

Many commenters requested the addition of definitions to help define the limits of the standards. Several commenters requested the definitions for the terms “arterial,” “collector,” “urban,” “rural,” and “paved” roads as contained in the standards. The terms may be defined by the road jurisdiction in accordance with MUTCD section 1A-9 until they are defined in the MUTCD. The FHWA is presently developing a notice of proposed rulemaking that will include these definitions.

The FHWA is currently considering, through a series of proposed rules, the addition of definitions for such terms in the future version of the MUTCD. The proposed definitions for the terms “arterial highway,” “collector highway,” and “traveled way” were published December 5, 1997, in Docket No. 97-3032 for potential inclusion in the future edition of the MUTCD. The other terms may be included in future proposed rules for the future edition of the MUTCD based on need and public requests. Example definitions which may be used for the terms in the marking standard contained herein are discussed in the “Definitions” section of this rulemaking.

One State commented that the terms “urban” and “rural” should not be defined in the MUTCD because various jurisdictions adequately, but differently, define these terms by statute, ordinance, or other regulation for the purposes of the marking standards. This final rule does not define “rural” and “urban,” but the terms are being defined as part of the MUTCD update.

Approximately fifty percent of the commenters recommended changing the criteria and/or their values within the marking standards. Approximately twenty five percent of the commenters regarding the center line criteria and twenty percent regarding the edge lines criteria proposed changing one or more of the proposed criteria for the average daily traffic (ADT) or the road width. The main reason for changing the criteria was to reduce costs and allow more engineering judgment. Thirty-five percent of the commenters recommended other types of criteria for marking installations, such as, engineering judgment, parking, curbs, speed, crash history, and pavement surface. These values may be added by the jurisdictions, but the FHWA believes the standards provide adequate and safety marking criteria based on the majority of public comments and studies. The FHWA modified the criteria values to reduce the number of roads that require the markings and added provisions for increased engineering judgment in marking placement.

The FHWA also changed the basis of the marking standard to use “traveled way,” as used in the NCUTCD and American Traffic Safety Services Association (ATSSA) proposals rather than “roadway” to eliminate the parking lanes from the width criteria issues discussed by many commenters in the width criteria. The FHWA chose to use “traveled way” instead of “roadway” because the AASHTO definition of “roadway” includes the shoulder, whereas the MUTCD definition does not.

Commenters also submitted several safety concerns related to the proposed requirements. Commenters indicated that using the term “roadway” rather than “traveled way” which was recommended in the NCUTCD and ATSSA proposed standards would necessitate the use of larger width criteria values to avoid potential unsafe traffic conflicts with vehicles in the parking lanes. The FHWA modified the requirements by basing the standards on traveled way width, which does not include the parking lanes, in place of roadway width.

The FHWA also added an engineering judgment provision which determines marking requirements for safety concerns, such as, the parking conflicts. Fifteen commenters indicated that the markings of some lower volume roads, such as, in residential areas, may cause increased speeds or additional traffic on these roads which could potentially reduce safety. They indicated that road users typically would expect and interpret the markings to indicate a major road and that residents typically resist such markings on their roads. Other commenters indicated that the types of crashes which occur at some locations, especially in municipalities, are not related to and would not be reduced by placing the markings.

The FHWA added a provision to allow engineering judgment for safety reasons which will assist jurisdictions in providing markings which improve safety. The FHWA also modified the proposed rule by increasing the traffic volume criteria values for roads requiring center lines to allow more engineering judgment on a larger number of lower volume roads.

The FHWA subsequently published a separate NPA on January 6, 1997, in FHWA Docket No. 97-47 including entire Part 3, Markings, for a proposed future version of the MUTCD. Based on the previous comments to Docket No. 96-15, the FHWA proposed alternative proposed standards, called Warrants, for center line and edge line markings that were similar to the proposed standards submitted by the NCUTCD for Docket No. 96-15.

Of the 32 commenters responding to the proposed Part 3, sixteen commenters discussed the alternative proposed standards for center line and edge line markings warrants. The commenters' main issues were similar to those submitted for Docket No. 96-15. Three commenters recommended the use of guidance rather than requirements. Four State DOT commenters discussed concern regarding additional cost and abilities of local jurisdictions to place and maintain additional required markings. Two commenters were concerned about the safe passing of parked vehicles when center line is in place on narrow roadways. Five commenters requested definitions for such terms as "arterial," "collector," "urban," "rural," "paved," and "refuge" contained in the proposed standards. Five commenters discussed the criteria and criteria values, including one State DOT, that indicated that the local jurisdictions would meet the proposed standards. The issues raised by commenters in this docket were similar to issues submitted by commenters and appropriately addressed by FHWA as discussed above for Docket No. 96-15.

### **Rulemaking Analyses and Notices**

Executive Order 12866 (Regulatory Planning and Review) and Dot Regulatory Policies and Procedures

The FHWA has determined that this action is not a significant regulatory action within the meaning of Executive Order 12866 or significant within the meaning of Department of Transportation regulatory policies and procedures. It is anticipated that the economic impact of this rulemaking would be minimal. Based on the information submitted to the FHWA, the FHWA has concluded that most of the required marking and much of the recommended markings in accordance with these standards are currently in place as a result of common engineering practices and, in some cases, State and local jurisdiction regulations and policies. The new standards will help assure that all road jurisdictions provide at least the required minimum markings when applicable. This change will require some, mostly local, jurisdictions, to provide the markings on some roads for the first time. The FHWA estimates that the additional costs nationwide to meet the new minimum requirements could total approximately \$10 million to \$20 million per year. This is based on an average of 1000 to 2000 local jurisdictions needing some additional markings at an average cost of \$20,000 per jurisdiction for markings with an average life cycle of 2 years. Additional costs may be incurred at a jurisdiction's judgment if they place

markings in accordance with the FHWA recommendations for markings. These costs, in most cases, are eligible for Federal or Federal-aid funding at the jurisdictions' judgment. Therefore, a full regulatory evaluation is not required.

### **Regulatory Flexibility Act**

In compliance with the Regulatory Flexibility Act (5 U.S.C. 601-612), the FHWA has evaluated the effects of this action on small entities, including small governments. This final rule may require the installation of some additional center line and edge line markings on roads in various jurisdictions. The FHWA estimates that the additional costs nationwide to meet the new minimum requirements could total approximately \$10 million to \$20 million per year. This is based on an average of 1000 to 2000 local jurisdictions needing some additional markings at an average cost of \$20,000 per jurisdiction for markings with an average life cycle of 2 years. These costs, in most cases, are eligible for Federal or Federal-aid funding at the jurisdictions' judgment. Based on this evaluation, the FHWA hereby certifies that this action would not have a significant economic impact on a substantial number of small entities.

### **Executive Order 13132 (Federalism)**

This action has been analyzed in accordance with the principles and criteria contained in Executive Order 13132 dated August 4, 1999, and it has been determined that this action does not have a substantial direct effect or sufficient federalism implications on States that would limit the policymaking discretion of the States. Nothing in this document directly preempts any State law or regulation.

The MUTCD is incorporated by reference in 23 CFR part 655, subpart F, which requires that changes to the national standards issued by the FHWA shall be adopted by the States or other Federal agencies within two years of issuance. These amendments are in keeping with the Secretary of Transportation's authority under 23 U.S.C. 109(d), 315, and 402(a) to promulgate uniform guidelines to promote the safe and efficient use of the highway. To the extent that these amendments override any existing State requirements regarding traffic control devices, they do so in the interests of national uniformity.

### **Unfunded Mandates Reform Act of 1995**

This rule does not impose a Federal mandate resulting in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of \$100 million or more in any one year. (2 U.S.C. 1531 et seq.).

### **Executive Order 12988 (Civil Justice reform)**

This action meets applicable standards in sections 3(a) and 3(b)(2) of Executive Order 12988, civil Justice Reform, minimize litigation, eliminate ambiguity, and reduce burden.

### **Executive Order 13045 (Protection of Children)**

We have analyzed this action under Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks. This rule is not an economically significant rule and does not concern an environmental risk to health or safety that may disproportionately affect children.

### **Executive Order 12630 (Taking of Property)**

This rule will not effect a taking of private property or otherwise have taking implications under Executive Order 12630, Governmental Actions and Interference with Constitutionally Protected Property Rights

### **Executive Order 12372 (Intergovernmental Review)**

Catalog of Federal Domestic Assistance Program Number 20.205, Highway Planning and Construction. The regulations implementing Executive Order 12372 regarding intergovernmental consultation on Federal programs and activities apply to this program.

### **Paperwork Reduction Act**

This action does not contain a collection of information requirement for purposes of the Paperwork Reduction Act of 1995, 44 U.S.C. 3501-3520.

### **National Environmental Policy Act**

The agency has analyzed this action for the purpose of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and has determined that this action would not have any effect on the quality of the environment.

### **Regulation Identification Number**

A regulation identification number (RIN) is assigned to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. The RIN contained in the heading of this document can be used to cross reference this action with the Unified Agenda.

### **List of Subjects in 23 CFR Part 655**

Design standards, Grant programs--transportation, Highways and roads, Incorporation by reference, Signs, and Traffic regulations.

The FHWA hereby amends chapter I of title 23, Code of Federal Regulations, part 655 as set forth below.

### **PART 655--TRAFFIC OPERATIONS**

1. The authority citation for part 655 continues to read as follows:

Authority: 23 U.S.C. 109(d), 114(a), 315, and 402(a); and 49 CFR 1.48(b).

Subpart F--Traffic Control Devices on Federal-Aid and Other Streets and Highways

2. Revise Sec. 655.601(a) to read as follows:

Sec. 655.601 Purpose.

\* \* \* \* \*

(a) Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), FHWA, 1988, including Revision No. 1 dated January 17, 1990, Revision No. 2 dated March 17, 1992, Revision No. 3 dated September 3, 1993, Errata No. 1 to the 1988 MUTCD Revision 3, dated November 1, 1994, Revision No. 4 dated November 1, 1994, Revision No. 4a (modified) dated February 19, 1998, Revision No. 5 dated December 24, 1996, Revision No. 6 dated June 19, 1998, and Revision No. 7 dated January 3, 2000. This publication is incorporated by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51 and is on file at the Office of the Federal Register, 800 North Capitol Street, NW., Suite 700, Washington, DC. The 1988 MUTCD, including Revision No. 3 dated September 3, 1993, may be purchased from the Superintendent of Documents, U.S. Government Printing Office (GPO), P.O. Box 371954, Pittsburgh, PA 15250-7954, Stock No. 650-001-00001-0. The amendments to the MUTCD titled, "1988 MUTCD Revision No. 1," dated January 17, 1990, "1988 MUTCD Revision No. 2," dated March 17, 1992, "1988 MUTCD Revision No. 3," dated September 3, 1993, "1988 MUTCD Errata No. 1 to Revision No. 3," dated November 1, 1994, "1988 MUTCD Revision No. 4," dated November 1, 1994, "1998 MUTCD Revision No. 5," dated December 24, 1996, "Revision No. 6," dated June 19, 1998, and "Revision No. 7" dated January 3, 2000 are available from the Federal Highway Administration, Office of Transportation Operations, HOTO, 400 Seventh Street, SW.,

Washington, DC 20590. These documents are available for inspection and copying as prescribed in 49 CFR part 7.

Issued on: December 22, 1999.

Kenneth R. Wykle,

Federal Highway Administration.

[FR Doc. 99-33806 Filed 12-30-99; 8:45 am]

BILLING CODE 4910-22-P

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**APPENDIX C**  
**LIST OF PARTICIPANTS**

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A total of 66 participants took part in the three workshops. Table 17 summaries the number of participants by agency type in each workshop. As can be see in this table, slightly over half of the participants represented state transportation agencies and the remainder represented local agencies. Table 18 summaries participation by geographic state. This table shows that 39 sates were represented by the 66 participants. Tables 19 through 21 lists the individual participants from each type of agency.

In addition to the participants, there were also several observers at each workshop. These observers were mostly FHWA personnel, but also included a few other individuals. Table 22 lists the observers at the three workshops.

**Table 17. Summary of Workshop Attendance**

<b>Workshop Location</b>	<b>Number of Participants</b>				<b>Observers</b>
	<b>State</b>	<b>County</b>	<b>City</b>	<b>Total</b>	
Washington	11	10	1	22	3
Louisiana	10	13	0	23	6
North Carolina	15	3	4	22	3
Totals	36	26	5	67	12
Percentage	54%	39%	7%	N/A	N/A

**Table 18. States Represented by Participants**

State	Number of Participants		State	Number of Participants	
	Local	State		Local	State
Alabama	2	0	Missouri	0	1
California	1	1	Nebraska	1	0
Colorado	2	0	Nevada	1	1
Connecticut	1	1	New York	2	1
Delaware	0	1	New Mexico	0	1
Florida	0	1	North Carolina	0	2
Georgia	0	1	North Dakota	0	1
Idaho	0	2	Ohio	1	1
Illinois	2	1	Oregon	2	0
Indiana	0	1	Pennsylvania	0	1
Iowa	1	1	Puerto Rico	0	1
Kansas	1	1	South Carolina	1	1
Louisiana	2	2	South Dakota	1	0
Maine	1	0	Texas	2	1
Maryland	0	1	Utah	0	1
Massachusetts	1	1	Virginia	0	1
Michigan	0	1	Washington	2	1
Minnesota	2	1	Wisconsin	0	1
Mississippi	1	1	West Virginia	0	1
Montana	1	0	Wyoming	0	1



**Table 19. List of State Agency Participants**

<b>Name</b>	<b>Agency</b>	<b>State</b>	<b>Workshop</b>
Beck, Rick	Minnesota Department of Transportation	MN	WA
Bourne, Stuart	North Carolina Department of Transportation	NC	NC
Bowser, Gary	Indiana Department of Transportation	IN	LA
Breneman, Art	Pennsylvania Department of Transportation	PA	LA
Brinkmeyer, Greg	Texas Department of Transportation	TX	LA
Brown, Bill	Washington State Department of Transportation	WA	WA
Brown, Jack A.	Florida Department of Transportation	FL	NC
Covlin, Allan	North Dakota Department of Transportation	ND	WA
Crouch, Tim	Iowa Department of Transportation	IO	WA
Fay, Robert	Massachusetts Highway Department	MA	NC
Gostovich, Mike	Wyoming Department of Transportation	WY	WA
Hall, Charles	Virginia Department of Transportation	VA	NC
Hinojos, Maria	New Mexico State Highway Transportation Department.	NM	LA
Ingwerson, Gene	Kansas Department of Transportation	KS	LA
Jones, Chris	Georgia Department of Transportation	GA	NC
Kellenberger, Jim	North Carolina Department of Transportation	NC	NC
Kenney, Bruce E.	West Virginia Division of Highways	WV	NC
Khan, Muhammad	Ohio Department of Transportation	OH	NC
Kozol, Debby	Wisconsin Department of Transportation	WI	WA
Lees, Fred	Maryland State Highway Administration	MD	NC
Lindsey, Rukhsana	Utah Department of Transportation	UT	WA
Littleton, Bruce E.	Delaware Department of Transportation	DE	NC
McDonald, Steve	Missouri Highway and Transportation Department	MO	LA
Meis, Gerry	Caltrans	CA	WA
Micali, John	Connecticut Department of Transportation	CT	NC
Mindrum, Mark	Nevada Department of Transportation	NV	WA
Silva, Roberto	Puerto Rico Highways and Transportation Authority	PR	NC
Sloan, Harry	New York State Department of Transportation	NY	NC
Smith, William	Louisiana Department of Transportation and Development	LA	LA
Stewart, Richard L.	South Carolina Department of Transportation	SC	NC
Sullivan, Clayton	Idaho Transportation Department	ID	WA
Van Over, Larry	Idaho Transportation Department	ID	WA
Vance, John	Mississippi Department. of Transportation	MS	LA
Wood, Kenneth	Illinois Department of Transportation	IL	LA
Young, Joseph	Louisiana Department of Transportation and Development	LA	LA
Zimmerman, Brian	Michigan Department of Transportation	MI	NC

**Table 20. List of County Agency Participants**

<b>Name</b>	<b>Agency</b>	<b>State</b>	<b>Workshop</b>
Blair, James	Benton County Public Works Department	OR	WA
Blanck, Duane	Crow Wing County	MN	WA
Cline, Kenneth	Smith County Road Department	TX	LA
Ellison, James	Pierce County Public Works	WA	WA
Fichtner, Royce	Marshall County	IO	WA
Flanagan, Richard	Calcasieu Parish Division of Engineering & Public Works	LA	LA
Flinn, Thomas	San Joaquin County Department of Public Works	CA	WA
Fowler, Jerry	Saline County Public Works	KS	LA
Hostler, Dan	Hall County Highway Department	NE	LA
Jaynes, Samuel	Monroe County	MS	LA
Klink, Robert W.	Beaufort County	SC	NC
Kochevar, Bob	City and County of Denver	CO	NC
Lawrence, James "Floyd"	Colbert County Road Department	AL	LA
Macchi, Richard	Bell County	TX	LA
Marek, Joseph	Clackamas County Department of Transportation and Development	OR	WA
Market, Charles	Calhoun County Highway Department	AL	LA
Meister, Bobby	Minnehaha County Highway Department	SD	WA
Miller, David	Medina County	OH	LA
Paulson, Tim	Yellowstone County Department of Public Works	MT	WA
Piekarczyk, James	Kankakee County Highway Department	IL	LA
Prater, Albert	Calcasieu Parish Division of Engineering and Public Works	LA	LA
Rheynard, Star	McDonough and Henderson Counties	IL	LA
Ribeiro, Ray	Nassau County Department of Public Works	NY	NC
Romer, Rich	Clark County Traffic Management Division	NV	LA
Rowe, Gary	Jefferson County	WA	WA
Sandberg, Wayne	Washington County Department of Transportation and Physical Development	MN	WA

**Table 21. List of City Agency Participants**

<b>Name</b>	<b>Agency</b>	<b>State</b>	<b>Workshop</b>
Brown, William R.	Town of Greenwich	CT	NC
Centa, Dan	City of Pueblo	CO	WA
Dore, Gregory	Town of Skowhegan	ME	NC
Stinson, Rick	Town of Danvers Department of Public Works	MA	NC
Szczepansky, Henry	City of Buffalo	NY	NC

**Table 22. List of Workshop Observers**

<b>Name</b>	<b>Organization</b>	<b>Workshop</b>
Basha, Mujeeb	AASHTO	NC
Dover, Byron	FHWA	NC
Frobig, Cal	FHWA	WA
Grouchy, David	Louisiana T <sup>2</sup> Center	LA
Hatzi, Peter	FHWA	LA, NC, WA
Hernandez y Espanosa, Gilberto R.	Mexican transportation agency	LA
Huckaby, Ernie	FHWA	WA
Pinet, Julio	Mexican transportation agency	LA
Robinson, Mike	FHWA	LA
Williams, Ron	FHWA	LA



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**APPENDIX D**  
**PRE-WORKSHOP QUESTIONNAIRE**

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**WORKSHOP ON IMPLEMENTATION OF MAINTAINED PAVEMENT  
MARKING RETROREFLECTIVITY GUIDELINES**  
**Pre-Workshop Questionnaire**

Name: \_\_\_\_\_  
Title: \_\_\_\_\_  
Agency: \_\_\_\_\_  
Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
Email: \_\_\_\_\_

1. What type of agency are you with?
  - City
  - County
  - State
  - Federal
  - Other (please describe)
  
2. What are your pavement marking responsibilities (check all that apply)?
  - Administrative (policy) responsibility
  - Engineering (selection and design) responsibilities
  - Application and/or inspection responsibilities
  - Financial (budget) responsibilities
  - Other (please describe)
  
3. How many miles of roadway is your agency responsible for?
  - a. Centerline miles:
  - b. Lane miles:Comments:
  
4. What percentage of the centerline miles are unpaved?
  
5. What percentage of the centerline miles of roadway have a centerline marking?
  
6. What percentage of the centerline miles of roadway have edge lines?
  
7. What are your agency's criteria for determining whether to use the following types of markings on its roadways:
  - a. Centerlines
  - b. Lane Lines
  - c. Edge Lines

8. What is your agency's annual budget for pavement markings?
  - a. How much of this budget is spent on replacement of markings by contract (labor+materials)?
  - b. How much of this budget is spent on replacement of markings by your own forces (labor+materials)?
  - c. What portion of the total budget is associated with equipment?
  - d. Please identify any other elements of the total budget:
  
9. What pavement marking materials are used in your jurisdiction? (Please indicate how much of each type of material by centerline mile of roadway or percent of total centerline mileage.)
  
10. What is the average unit cost (\$/ft) to install pavement markings in your jurisdiction? Please provide this information for each type of pavement marking material you use.
  
11. Does your agency use raised pavement markings?
 

Yes                       No

 If yes, at what spacing?
  
12. How often do you replace raised pavement markings?
  
13. Does your agency snowplow its roads? If yes, approximately how many times per year?
  
14. Does your agency have a regular pavement marking maintenance program?
 

Yes                       No

 If yes, please describe:
  
15. Does your agency have any form of a pavement marking management system?
 

Yes                       No

 If yes, please describe:
  
16. How many pavement marking retroreflectometers does your agency own? Please indicate the type/model of each type of pavement marking retroreflectometer. Please indicate whether the instrument(s) use 12 meter or 30 meter geometry.
  
17. Has your agency contracted with any outside sources to assist with a pavement marking evaluation or assist in establishing a pavement marking management program? If so, please briefly explain.
  
18. Does your agency conduct regularly scheduled nighttime visual inspections of pavement marking retroreflectivity?
 

Yes                       No

 If yes, how often?

19. Does your agency measure the retroreflectivity of pavement markings when they are installed?  
 Yes                       No (skip the next question)  
Comments:
20. If measured when the markings are installed, is the measurement associated with a performance specification?  
 Yes                       No  
If yes, what is the minimum retroreflectivity that is required to accept the marking?
21. Does your agency measure the retroreflectivity of pavement markings at various times during their service life?  
 Yes                       No (skip the next question)  
Comments:
22. If measured during their service life, is the measurement used as the basis for determining when to replace the pavement markings?  
 Yes                       No  
If yes, what is the minimum retroreflectivity that is required to accept the marking?
23. How does your agency decide when to replace existing pavement markings?  
Examples of responses (other responses may also be appropriate):  
    Replace 100 percent of markings every Spring.  
    Replace all paint every year and epoxy every 3<sup>rd</sup> year.  
    Evaluate the markings x times a year with retroreflectometers and make decisions based on the measurements.
24. What do you believe is the minimum level of pavement marking retroreflectivity that is needed by drivers to safely operate a vehicle at night? You may structure your response according to roadway classification, traffic volume, speed, or other factors.
25. What methods does your agency use to determine if your pavement markings are meeting the needs of drivers?  
Examples of responses (other responses may also be appropriate):  
    Retroreflectometer readings compared to research.  
    Visual inspection and subjective decision.  
    History of what seems to work.  
    Public complaints?
26. Within the last ten years, has the retroreflectivity of pavement markings been an issue in any tort claims against your agency?
27. Within the last ten years, has the retroreflectivity of pavement markings been the primary focus of any tort claims against your agency?

28. What actions has your agency taken to prepare for the introduction of minimum levels of retroreflectivity for pavement markings?
29. What actions would your agency take if minimum levels of pavement marking retroreflectivity are published in the next MUTCD?
30. If the FHWA establishes minimum levels of retroreflectivity for pavement markings, what do you believe would be the primary concern(s) of your agency?
31. Any other comments related to minimum levels of in-service retroreflectivity for pavement markings.

Please return the survey by fax or mail to:

Dwight Horne  
Director  
Office of Safety Infrastructure  
HMHS - Room 3103

Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
Fax: (202) 366-2249

Surveys should be returned at least one week prior to your workshop. Thank you.



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## APPENDIX E

# POST-WORKSHOP EVALUATION

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At the end of the second and third workshops, the facilitators distributed a two-page evaluation form to the participants to gather opinions on the quality of the workshop and participants opinions regarding the workshop results. The evaluation form consisted of nine questions. For each question, participants selected a response of: *Strongly Agree*, *Somewhat Agree*, *Neutral*, *Somewhat Disagree*, or *Strongly Disagree*. At the end of the nine questions was an opportunity to provide general comments on the workshop.

The nine questions included in the evaluation form were:

1. The workshop modules were well organized:
2. I found the technical information presented in the workshop to be very helpful and informative:
3. The nighttime demo for this workshop was a vital part of understanding the issue of minimum levels of retroreflectivity for pavement markings:
4. The instructors for this course were acceptable:
5. The meeting room for this workshop was acceptable:
6. The hotel accommodations for this workshop were satisfactory:
7. Overall, I am: very glad that I attended the workshop:
8. Minimum in-service levels of retroreflectivity for pavement markings will improve the safety of public roads:
9. I feel comfortable that minimum in-service levels of retroreflectivity for pavement markings have the potential to be implemented with little burden on public agencies:

Figure 7 illustrates the appearance of the evaluation form condensed to one page. The evaluation was not distributed at the first (Washington) workshop.

Responses to the nine questions in the evaluation form are summarized for the second (Louisiana) and third (North Carolina) workshops in Table 23. Numerous individuals also offered general comments (17 of 22 in Louisiana and 7 of 21 in North Carolina). The general comments are summarized in Figure 24 (state personnel) and Figure 25 (county and city personnel).

**FHWA PAVEMENT MARKING RETROREFLECTIVITY WORKSHOP  
EVALUATION AND COMMENT FORM**

Name: \_\_\_\_\_

Organization: \_\_\_\_\_

Workshop Location: \_\_\_\_\_

1. **The workshop modules were well organized:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
2. **I found the technical information presented in the workshop to be very helpful and informative:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
3. **The nighttime demo for this workshop was a vital part of understanding the issue of minimum levels of retroreflectivity for pavement markings:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
4. **The instructors for this course were acceptable:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
5. **The meeting room for this workshop was acceptable:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
6. **The hotel accommodations for this workshop were satisfactory:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
7. **Overall, I am:very glad that I attended the workshop:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
8. **Minimum in-service levels of retroreflectivity for pavement markings will improve the safety of public roads:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree
9. **I feel comfortable that minimum in-service levels of retroreflectivity for pavement markings have the potential to be implemented with little burden on public agencies:**  
 Strongly agree     Somewhat agree     Neutral     Somewhat disagree     Strongly disagree

**GENERAL COMMENTS:**

**Figure 7. Workshop Evaluation Form**

**Table 23. Summary of Workshop Evaluation Results**

Question		Location	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
1.	The workshop modules were well organized:	LA	15	6	0	0	0
		NC	14	7	0	0	0
2.	I found the technical information presented in the workshop to be very helpful and informative:	LA	16	4	1	1	0
		NC	14	6	1	0	0
3.	The nighttime demo for this workshop was a vital part of understanding the issue of minimum levels of retroreflectivity for pavement markings:	LA	8	10	3	1	0
		NC	14	3	3	0	0
4.	The instructors for this course were acceptable:	LA	17	5	0	0	0
		NC	20	1	0	0	0
5.	The meeting room for this workshop was acceptable:	LA	18	3	1	0	0
		NC	13	6	1	1	0
6.	The hotel accommodations for this workshop were satisfactory:	LA	6	12	3	0	0
		NC	4	11	2	2	0
7.	Overall, I am very glad that I attended the workshop:	LA	21	1	0	0	0
		NC	20	1	0	0	0
8.	Minimum in-service levels of retroreflectivity for pavement markings will improve the safety of public roads:	LA	6	8	2	5	1
		NC	11	8	1	1	0
9.	I feel comfortable that minimum in-service levels of retroreflectivity for pavement markings have the potential to be implemented with little burden on public agencies:	LA	2	4	2	9	5
		NC	2	5	2	8	4

## **STATE PERSONNEL**

### **Question #2:**

! More data was needed on  $R_L$  values (what is really acceptable as minimum.).

### **Question #3:**

! Night review: Dynamic, needs longer sections.

### **Question #5:**

! A little cold.

### **Question #6:**

! Hot tub needed.

### **Question #7:**

! [This state] would like to be included in other workshops like this when policies are decided.

### **Question #8:**

! Only if quality was lacking and this will bring it out in open (don't know at this time).

! Safety - subjective because of lack of data. (Comfort)

### **Question #9:**

! A change in procedures will be needed. There will be additional burdens that aren't related to increased costs. Money may be the lowest concern.

! Okay at the state level, but at a lower level, this will be a burden.

### **Overall:**

! Need to provide a look at data from Graham/Migletz concerning local roads.

! When inviting people, be more specific and mention that this is in response with the new law on retroreflectivity and that seeking input for your ruling.

! Might mention that if enough time is given prior to the workshop, that local agencies borrow a reflectometer from the state and do their sampling as to what they have now as values. That way when they come to the seminar, they have some idea as to what the values mean. (3 months is enough time.) Better feel for the values.

! Counties have a gripe that is justified. But it has been no secret about minimum levels.

! I feel that with 3 months plus time to participate, some representatives were ill-prepared with their knowledge of pavement markings and pavement markings in their own jurisdiction, especially performance of their material.

! Thanks for the opportunity to participate. Nice to see FHWA [UNABLE TO READ].

! Gene/Greg/Jim/Rick - Thanks.

! I appreciate the opportunity to attend and be a part of this process.

! Probably would have been useful to observe more poor markings the first night. Otherwise, workshop was informative of upcoming rules. We need to get working on preparations.

! Thanks NC DOT for hosting and transportation.

! Understand issue with snow plowing - unpredictable and thus the concern.

! States that are measuring what they have - help support the proposed values are reasonable - but budget over rules customer needs.

! Really good interaction with peers.

! Marking materials module should be omitted. Participants in this workshop should be fundamentally prepared for the true.

! It appears that the majority of all agencies have no clue as to what is about to happen. A very strong education/information program will be necessary to accomplish this goal. It is very possible that cities and counties may never be able to meet the requirements, leaving them in a poor position to defend themselves. This goal, however, needs to be accomplished.

**Figure 8. General Comments from State Personnel**

## **COUNTY PERSONNEL**

### **Question #9:**

- ! Larger agencies will have no problem meeting requirements. Smaller ones will.

### **Overall:**

- ! Thank you for coming to LA with this workshop.
- ! This workshop has been a great forum for hearing from other agencies regarding their concerns. This exchange should help arrive at a better end result.
- ! We need a system that a small county can afford to do with their personnel.
- ! I believe that every possible effort should be made to structure the retroreflectivity requirements in a manner that will minimize the tort (?) liability to the various agencies.
- ! Comments were given orally. I do think that county participants in the conference should be given more time at night to view pavement markings of varying retroreflective qualities and maybe actually measuring those qualities on site.
- ! The workshop failed to demonstrate the benefits of this proposal in terms of crash reduction. The thinking among some of us is that it may help, but are we right? We have heard of some studies which suggest an increase in crashes due to enhanced pavement marking visibility.
- ! If too high minimums are adopted, small agencies will have budgets busted unless a system of non-measurement based inspections or in other words low cost systems are allowed. Increases in safety on our roads based upon higher minimum retroreflectivity requirements has not been proven to my satisfaction, thereby, bringing into question the reason for this exercise. One Minnesota legislator got the legislation passed bringing into question what congress was really after or simply what this particular legislators' motives were. I for one, and I suspect many others, especially in small agencies, will oppose these types of unfunded mandates as an intrusion upon our agencies' right to take care of our own without federal mandates telling us how we are to do things in our jurisdictions where they do not know our specific conditions.
- ! Need to subsequently develop an outreach program with professional societies, T<sup>2</sup> (LTAP), to disseminate information. Generally, provide an environment that is receptive and open to comment without any recrimination to ensure that the goal of receiving input and feedback is achieved. Information/research that relates to local agencies, not only state DOT's, is essential to achieve goal of local agency input and feedback. This was lacking and appeared that there was little understanding or concern of the local agency perspective and situation. Opportunity to participate was sincerely appreciated.

## **CITY PERSONNEL**

### **Overall:**

- ! I feel those who are painting now are doing a good job. Those who aren't will continue not to comply.
- ! Facilities were well prepared and presented workshop materials well.
- ! MN DOT presentations on road survey and management system were very helpful. Thank you for including me.
- ! Information was organized and made easy to understand.
- ! All speakers had excellent information and easy to talk to.

**Figure 9. General Comments from County and City Personnel**



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**APPENDIX F**  
**RECOMMENDED MUTCD LANGUAGE**

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This appendix presents the MUTCD language recommended by the workshop facilitators for establishing minimum levels of pavement marking retroreflectivity. There are several aspects of the recommended MUTCD language that require additional research to establish threshold values. In these cases, the unknown values are indicated by ??. Where threshold values are unknown, a note is also provided addressing the need to develop the threshold values.

### 3A.?? Minimum Retroreflectivity for Pavement Markings

#### Support

Retroreflectivity of pavement markings is necessary to provide drivers with the necessary delineation of the roadway in nighttime conditions.

#### Guidance:

*When the retroreflectivity of longitudinal pavement markings (centerlines, no passing lines, lane lines, and edge lines) falls below the values shown in Table 3A-1, the markings should be scheduled for replacement as soon as conditions and resources permit.*

**Table 3A-1. Minimum Values for Pavement Marking Retroreflectivity (speed based)**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	≤ 30 mph	35-50 mph	≥55 mph
White	Presence <sup>3</sup>	80	100
Yellow	Presence	65	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

#### Option:

An agency may use the retroreflectivity values shown in Table 3A-2 in lieu of the values in Table 3A-1.

**Table 3A-2. Minimum Values for Pavement Marking Retroreflectivity (classification based)**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	Local and Minor Collector	Major Collector and Arterial	Highways, Freeways and all roads ≥55 mph
White	Presence <sup>3</sup>	80	100
Yellow	Presence	65	80

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.



**Standard:**

The minimum values shown in Tables 3A-1 or 3A-2 shall not apply to markings that are not required by a standard or guidance statement in sections 3B.1 or 3B.6 of this Manual.

**Option:**

The minimum values shown in Table 3A-1 may be reduced to those shown in Table 3A-3 if a marking line is supplemented by retroreflective raised pavement markers or if continuous roadway lighting is present.

**Table 3A-3. Reduced Minimum Retroreflectivity Values for Pavement Markings (speed based)**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	≤ 30 mph	35-50 mph	≥55 mph
White	Presence <sup>3</sup>	35	50
Yellow	Presence	35	40

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

The minimum values shown in Table 3A-2 may be reduced to those shown in Table 3A-4 if a marking line is supplemented by retroreflective raised pavement markers or if continuous roadway lighting is present.

**Table 3A-4. Reduced Minimum Retroreflectivity Values for Pavement Markings**

Marking Color	Minimum $R_L$ <sup>1</sup> (mcd/m <sup>2</sup> /lux) for Indicated Speed <sup>2</sup>		
	Local and Minor Collector	Major Collector and Arterial	Highways, Freeways and all roads ≥55 mph
White	Presence <sup>3</sup>	35	50
Yellow	Presence	35	40

**Notes:**

<sup>1</sup>  $R_L$  measured at 30 meter geometry.

<sup>2</sup> Speed is the posted or statutory speed.

<sup>3</sup> Presence is a visible pavement marking at night, but with no retroreflectivity value.

**Standard**

For the minimum values to be reduced to the values shown in Tables 3A-3 or 3A-4 on roads with retroreflective raised pavement markings, the retroreflective raised pavement markers must meet all of the following conditions:

- a. **The marking to which the reduced retroreflectivity values are applied shall be supplemented by retroreflective raised pavement markers.**
- b. **The initial spacing of retroreflective raised pavement markers shall be no greater than ?? feet.** NOTE TO FHWA – Research is needed to determine the maximum spacing between retroreflective raised pavement markers. This is probably somewhere in the 80 to 120 feet range. The spacing issue was not addressed in the workshops. It may be more appropriate to address the maximum spacing between any two retroreflective raised pavement markers that addresses how many consecutive retroreflective raised pavement markers can be missing. This should probably be something close to the preview distance and might vary according to the speed of the roadway.
- c. **Retroreflective raised pavement markers shall have retroreflectivity values greater than ??.** NOTE TO FHWA – Research is needed to determine the minimum retroreflectivity value for retroreflective raised pavement markers. The FHWA may want to consider applying the minimum value to some portion of consecutive retroreflective raised pavement markers (i.e., two out of four consecutive markers shall have a retroreflectivity value of ??).

**For the minimum values to be reduced to the values shown in Tables 3A-3 or 3A-4 on roads with continuous roadway lighting, the roadway lighting must meet all of the following conditions:**

- a. **The minimum illumination at all longitudinal pavement markings shall be no less than ?? lux.** NOTE TO FHWA – Research is needed to determine the minimum luminance that is appropriate to allow a reduction in the retroreflectivity values.
- b. **The roadway lighting shall be operative at all times when the ambient illumination is less than ??.** NOTE TO FHWA – Research is needed to determine the ambient lighting level at which the roadway illumination should be used.

Option:

Compliance with the minimum retroreflectivity values provided in Tables 3A-1 through 3A-4 may be provided through any one of the following methods:

- a. Measurement of pavement marking retroreflectivity.
- b. Nighttime visual inspections.
- c. Pavement marking management system.

*Guidance:*

*Measurements of pavement marking retroreflectivity should include the following factors:*

- a. *Measurements should be taken a minimum of once a year. If an annual measurement interval is used, it should be representative of the marking throughout the year and not representative of a new marking.*
- b. *Pavement marking retroreflectivity measurements should be taken of a representative sample of the pavement markings in the jurisdiction.* NOTE TO FHWA – Research is

*needed to develop guidelines on sampling procedures for pavement marking retroreflectivity measurements.*

*Nighttime visual inspections of pavement marking retroreflectivity should include the following factors:*

- a. The acceptance criteria for pavement marking visibility should be based on the minimum retroreflectivity values shown in Tables 3A-1 through 3A-4.*
- b. Nighttime visual inspections should be conducted a minimum of once a year.*
- c. Individuals conducting nighttime visual inspections should consider the visual limitations of the older driver population.*

*Pavement marking management systems should include the following factors:*

- a. Replacement of pavement markings should be based on expected life of pavement marking retroreflectivity using the retroreflectivity values in Tables 3A-1 through 3A-4.*
- b. Predictions of pavement marking life should be based on measurements of pavement marking retroreflectivity of an appropriate sample of markings within the jurisdiction.*