FINAL REPORT

NCHRP PROJECT 20-07 TASK 310

DETERMINATION OF CURRENT LEVELS OF RETROREFLECTANCE ATTAINED AND MAINTAINED BY THE STATE DEPARTMENTS OF TRANSPORTATION

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Transportation Research Board
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INTRODUCTION

The Federal Highway Administration (FHWA) has started rule-making efforts to establish minimum maintained pavement markings retroreflectivity levels in the *Manual on Uniform Traffic Control Device* (MUTCD) (*1, 2*). The proposed MUTCD language contains minimum pavement marking retroreflectivity levels that are based on vehicle speed and pavement marking configuration. There are also certain exemptions depending on roadway lighting presence, raised retroreflective marker presence and condition, and traffic volumes. The full proposed MUTCD language is included in Appendix A.

The FHWA has received comments to the proposed MUTCD language but has not yet issued a response with required minimum levels of retroreflectivity. AASHTO provided comments (shown in Appendix B) to the FHWA's proposed MUTCD language. This report is a result of the study referenced in item 5 of AASHTO's comments.

Many factors impact the integrity of the retroreflectivity of pavement markings, including but not limited to, type of marking, type of facility, condition of the pavement, type and volume of traffic, climatic conditions, and maintenance activities over the life of the marking – including the use and frequency of deicing materials and snow removal activities.

In northern climates, where winter maintenance activities such as snow plowing and snow removal are frequent, pavement marking retroreflectivity becomes difficult to maintain until the warmer and dryer weather of summer approaches (when road striping crews can start refurbishing the markings). In these areas, it can be difficult to maintain pavement marking presence throughout the winter months, let alone retroreflectivity. State Highway agencies are interested in understanding the condition of existing markings with a focus on the degradation of pavement markings between normal striping seasons.

BACKGROUND

State and Federal Highway agencies have exhibited a historical interest in understanding the life and effectiveness of pavement markings for some time. The first FHWA report proposing a minimum retroreflectivity level based on the types of facilities, colors and conditions was authored in 1999 by J. D. Turner (3). Subsequent research has produced recommendations for minimum retroreflectivity levels ranging from a low of 40 mcd to a high of 575 mcd (4,5,6).[1] The lowest recommendation was for a slow speed facility with fully marked roadways including center line, lane lines, and/or edge lines. The highest recommended level was for a high speed facility (in excess of 70mph) with only center lines and no lane lines or edge lines. Retroreflectivity readings in the range of 80 mcd to 100 mcd are considered by some state agencies as the threshold for restriping (4). Other research focused on determining the relationship between pavement marking optics and nighttime visibility (7).

The Commonwealth Pennsylvania Department of Transportation sponsored work in 2008 to report the State-of-the Practice in 19 states with similar characteristics to learn how they could improve the visibility and life of PENNDOT pavement markings (8). PENNDOT followed this with additional research to develop a comprehensive analysis database that could be used to create a pavement marking management system for both waterborne and durable pavement markings on a variety of types of roadways (9). This research also produced degradation curves that could be used to estimate appropriate times for restriping pavements. The North Carolina Department of Transportation also sponsored research to develop degradation models for thermoplastic and paint pavement markings and provided a framework for estimating the current and future conditions of pavement markings (10). Washington State Department of Transportation initiated research that developed retroreflectivity degradation curves to evaluate the effective service life of their pavement markings and help determine proper restriping schedules (11). Another study that estimated the service life of a variety of types of pavement markings was developed using NTPEP data from Mississippi in a 2006 paper published through the Transportation Research Forum (12).

A variety of other research was discovered ranging from a study from The Pennsylvania State University seeking to replicate degradation of a variety of pavement markings using accelerated wear testing in a laboratory setting (13) to an Ohio study focusing on the pavement markings on bridge decks (14). Other work evaluated completed research and practices to focus on the current methodologies and practices being used and make observations on the combined efforts of other research (5,8,15).

[1] In this report, mcd is used to represent the units of pavement marking retroreflectivity, which is more formally known as the coefficient of retroreflected luminance with the units mcd per square meter per lux.

RESEARCH OBJECTIVE AND APPROACH

The objective of this research is to assess the retroreflectivity of lane markings attained and maintained throughout the winter season in different exposure conditions across the United States. This assessment will aid in determining a reasonably attainable level and provide assurance to the state agencies that such levels can be maintained over the winter. This will be accomplished by analyzing data from State Highway Agencies and also from analyzing available data from the National Transportation Product Evaluation Program (NTPEP) from selected states. The steps to accomplish the work are listed below:

TASKS

Task 1. Collect and analyze data on the initial retroreflectivity of traffic marking lines in the 2010 striping season:

a. Collect data from six or more states with current monitoring programs for traffic marking line application.
b. Categorize the selected states between snow belt or non-snow belt and maintenance program or no maintenance program, and determine the equipment utilized to obtain retroreflectivity readings. A minimum of four states shall be in the snow belt, defined as states that typically experience multiple snow events and utilize various deicing and plowing regimes for maintaining the driving surface during the winter months. If possible, quantify snow plow activity and/or deicing activity. A minimum of two states shall be categorized as non-snow belt, defined as states that do not employ snow plows, but may utilize deicing salts.
c. In addition to the retroreflectivity data from each state, determine the following information, if possible:
    i. Methods of obtaining data including (1) frequency of collection, (2) type/model of equipment/instrumentation, including allowable variability, (3) hand held versus mobile, (4) 30-meter versus 15-meter or other, (5) same line and location versus random sampling and testing at various locations, (6) white versus yellow markings, (7) skip lines versus edge lines or center lines, and (8) interstate, secondary roadways, or rural two-lane roadways.
    ii. Criteria for discarding readings from dataset.
    iii. Criteria for (1) restriping due to poor initial readings and (2) discarding lower initial readings if restriping takes place.

Task 2. Collect and statistically analyze retroreflectivity data on lines evaluated in Task 1 after exposure over a 6-month winter period (These data may actually be obtained on 1-year-old traffic marking lines.):

a. Compare data between snow belt and non-snow belt states, including information on states using deicing salts on roadways.
b. Determine typical retroreflectivity values before and after winter exposure to snow plow and deicing salts.

Task 3. Analyze the one year data collected through active National Transportation Product Evaluation Pavement Marking (NTPEP) test decks in Minnesota, Florida, and Pennsylvania to establish general trends in reduction in retroreflectivity of non-temporary pavement marking lines of various materials with attention to the following:

a. Differences in performance between in the wheel track and out of the wheel track
b. Differences in products performing at various levels of retroreflectivity
c. Marking type, i.e. paint, thermoplastic, or tape
d. Type, size, and quantity of glass beads, including the use of double drop beads

Task 4. Prepare a final report that presents statistical comparisons of the datasets, summarizes performance trends, and projects reasonably attainable values and expectations for the retroreflectivity of paint, thermoplastic, and tape traffic marking lines after a winter season. In preparing the report:

a. Provide data in a manner to differentiate between markings subjected to snow plowing and deicing compared with markings not subjected to such winter maintenance.
b. If available, include relevant data from previously completed state agency studies in the analysis.
c. Provide guidance regarding suggested restriping program for snow belt states versus non-snow belt states:
    i. What retroreflectivity values should be expected after a defined period of time for (1) white and yellow marking materials, (2) edge, skip, and centerline markings, and (3) interstate, primary, and secondary roadways?
    ii. What is a realistic time period that a pavement marking will maintain a defined value of retroreflectivity for (1) white and yellow marking materials, (2) edge, skip, and centerline markings, and (3) interstate, primary, and secondary roadways?

FIELD DATA

In order to identify field data for this project, an email was sent to AASHTO SCOTE members in July 2011 (see below). In addition, while attending national conferences such as TRB, NCUTCD, ASTM, and AASHTO SOM, brief presentations were made introducing the project and goals and concluding with requests for participation.

Howdy! As you know, the FHWA has issued a NPA for minimum pavement marking retroreflectivity levels for the MUTCD. In order to better understand how pavement marking retroreflectivity wears over the winter months, we are requesting your help with NCHRP Project 20-07 (Task 310) - *Determination of Current Levels of Retroreflectance Attained and Maintained by the State Departments of Transportation* http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3074. I am working on this project with Cecil Jones, Diversified Engineering Services, Inc.

We are looking for a sample of state DOT pavement marking data that we can use to assess the degradation of retroreflectivity during the winter months. The necessary criteria we need are:

- Retroreflectivity measurements of new markings during the summer/fall and retroreflectivity measurements from the same markings during the following spring/summer.
- Type of pavement marking binder (e.g., paint, thermoplastic, epoxy, etc) and optic (AASHTO Type I bead, Type II bead, double drop, etc.) for each set of measurements.
- If pavement marking was in a groove (if so, how deep) or surface applied.
- Type of pavement marking: yellow edge line, yellow center line, white lane line, or white edge line.
- Roadway classification (e.g., Interstate, rural two-lane roadway, etc.) and roadway volume.

If available, we are also interesting in the following information:

- Number of snow plow events and or deicing events during the winter months associated with the retroreflective data
- Pavement type and condition
- Methods used to obtain retroreflectivity readings: hand-held versus mobile device
- Minimum levels for initial retroreflectivity measurements
- Criteria for restriping if initial retroreflective measurements are inadequate
- Minimum retroreflectivity levels for in-service pavement markings

We would like to get as much data as possible. You can send it in any form that is convenient. Please let us know by this Friday (July 15) if you have the necessary data to assist with this project. If you can send your data this week, it would be greatly appreciated. Please feel free to share this request with others in your agency if more appropriate.

If you have any questions, please let us know. Thanks!

We requested the data in any form that was convenient for the state in hope of receiving more responses. Follow up written and verbal requests were also made.

Data has been received as a result of the letters and verbal requests. Additional data were also used from previous state research. We have evaluated fall and spring retroreflectivity data from nine (9) states. As expected, the data was received in a wide variety of formats and varying degrees of responses to all of the requested information. Some states had most of the requested information, while others submitted information that contained less of the desired details. For example, little data was received that included the details of the number of snow plow events and limited information about the optics was received. No tape data was submitted by the states providing information, therefore no analysis of tapes is possible. The FHWA has reported that the typical distribution of pavement marking includes 75% of the total being paint, 20% are thermoplastic and the remaining 5% is classified as "other" which includes epoxy, tapes, etc. (6). The NTPEP data being evaluated for Task 3 has more detailed optics data, but although the NTPEP protocol included reporting forms for capturing snow plow cycle data, almost none was collected and reported.

The states supplying data have been classified into two classes as shown in Table 1; Snow Belt States, which typically experience multiple snow events per year; and Non-Snow Belt States, which may experience some snow, but do not need to treat it as aggressively as the other classification.

Table 1. Classification of States

Snow Belt States (7)	Non-Snow Belt States (2)
New Hampshire Maine Iowa Wisconsin Michigan Pennsylvania West Virginia	Tennessee North Carolina

Most of the information received was provided from the State Highway Agency's own efforts to maintain pavement marking retroreflectivity but some of the West Virginia data and all of the Tennessee data came from longitudinal pavement marking test decks. In addition to the retroreflectivity data, other information was also received such as the type of measurement device, sampling protocol, pavement marking color and type, roadway classification, and traffic volume. As noted earlier, very limited information was provided with details about the number of snow plow events. In some cases, such as North Carolina, specific dates of initial application of markings or follow up measurements were not given, but measurements were taken at six month intervals for multiple years. The number of readings taken was not always consistent for the same segment of pavement for each measurement cycle in some states. Table 2 summarizes the data received from the states. Appendix C is a summary of both state data received and NTPEP data that includes information, if received, about the type of line, type of marking, manufacturer and product name, thickness, optics, bead type and loading rate, installation date, and dates that retroreflective readings were taken.

Information from this spreadsheet provided the basis of our analysis and findings. Some of the retroreflective readings in Appendix C were excluded from use in our analysis because the readings increased from the fall to the spring readings beyond what would seem reasonable. It is possible for the readings to increase after time due to a range of factors including the use of premium beads, no aggressive maintenance activities (not likely in a snow belt state), or recent rainfall cleaning dust from the exposed beads. Engineering judgment was used during the analysis to discard any readings that were obviously incorrect. The limited number of readings that were discarded had increases well beyond what our team felt could reasonably be expected. The readings exhibiting an increase after the spring are highlighted in yellow in the detailed data of Appendix C.

Table 2. Field Data Received

State	Line Type*	Binder Type**	ADT	Snow plow events	30-Meter Retroreflectivity equipment used	Quantity of Retroreflectivity measurements
Tennessee	EL, LL	AWP, ET, ST, HBP, IPT, LTP, P	y	n	Handheld	2448
New Hampshire	EL, CL	WP	y	y	Handheld	1760
Maine	CL	WP	n	n	Handheld	881
Iowa	EL, CL, LL	WP	n	n	Handheld	19334 1-mile averages
Wisconsin	EL, CL, LL	E, WP	n	n	Handheld	557
Michigan	EL, CL, LL	WP	n	n	Mobile	13469
Pennsylvania	EL, CL	WP	y	n	Handheld	659
North Carolina	EL, CL, LL	E, ST, ET, WP, P	n	n	Mobile	***
West Virginia	EL, LL	E, MMA, P	Y	n	Handheld	3500

*EL=Edge Line; LL=Lane Line; CL=Center Line

**AWP=All Weather Paint; ET=Extruded Thermoplastic; ST=Sprayed Thermoplastic; HBP=High Build Paint; IPT=Inverted Profile Thermoplastic; LTP=Low Temperature Paint; WP-Waterborne Paint; E=Epoxy; P=Polyurea; MMA=Methyl Methacrylate

***data were provided in aggregate

First Winter Retroreflectivity Loss

The majority of the supplied state data included paint with standard sized beads (AASHTO M247 Type I or a similar state-specified version). Therefore, this section focuses mainly on data from pavement markings made with paint and standard sized beads.

Figure 1 shows the average retroreflectivity readings from the state data for white edge lines marked with paint. The first set of bars represents the average retroreflectivity from edge lines installed during the same year. The second grouping of bars on the right represents the average retroreflectivity from the same edge lines during the following spring. For some states, more than one year of data were available (noted in the legend with a number following the name of the state to indicate the unique sets of data). In summary, this graph shows the typical drop in retroreflectivity experienced during the first winter for eight different states. Overall, the average fall retroreflectivity level was 326 mcd, and the average drop over the winter was 175 mcd, leaving an average of 159 mcd after the winter. The average retroreflectivity for white edge lines remained above 100 mcd for all the data provided. The average first winter drop in retroreflectivity for the snow belt states was 175 mcd, compared to a drop of 67 mcd for the two non-snow belt states.

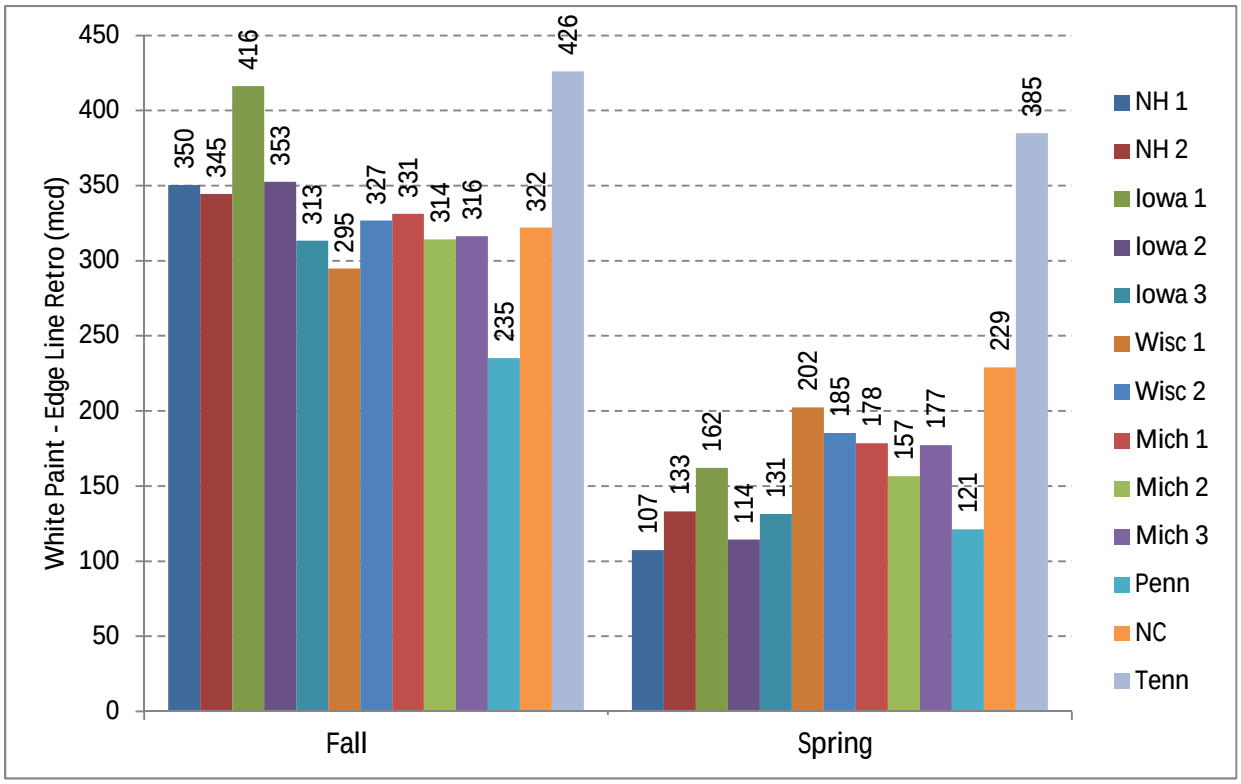

Figure 1. Fall and Spring Retroreflectivity Readings for White Paint on Edge Lines

Figure 2 shows data in the same format as above expect for yellow center line retroreflectivity data provided by the states. For yellow centerlines, the overall fall average was 209 mcd and those lines

experienced an average drop of 110 mcd during their first winter leaving an average retroreflectivity level of 99 mcd in the spring. The Snow Belt states experienced a much more dramatic drop in center line retroreflectivity during the winter season compared to North Carolina (106 mcd versus 35 mcd).

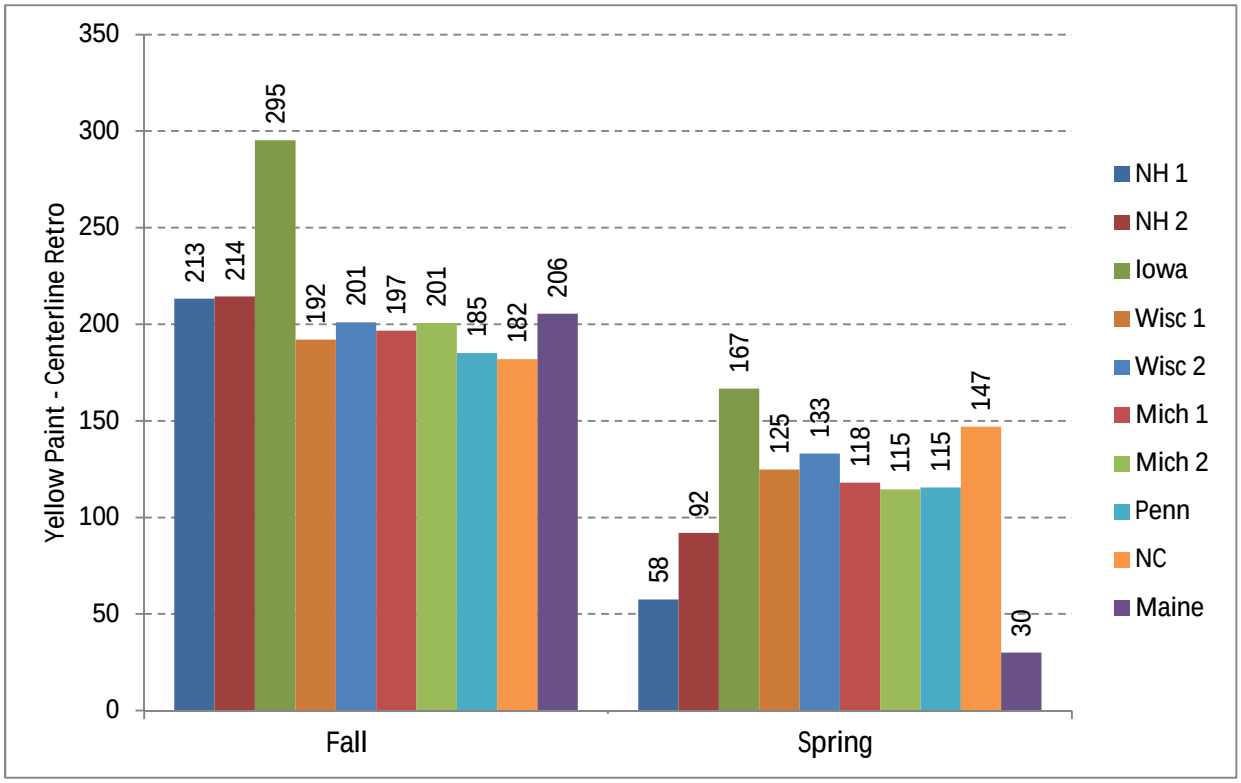

Figure 2. Fall and Spring Retroreflectivity Readings for Yellow Paint on Centerlines

Similarly, Figure 3 uses the same formatting except this one was generated using data for white lane lines supplied by the states. The average fall retroreflectivity was 348 mcd for Snow Belt states versus 372 mcd for non-Snow Belt states. Snow Belt states experienced an average loss in retroreflectivity of 171 mcd over the winter months compared to 114 mcd for the non-Snow Belt states.

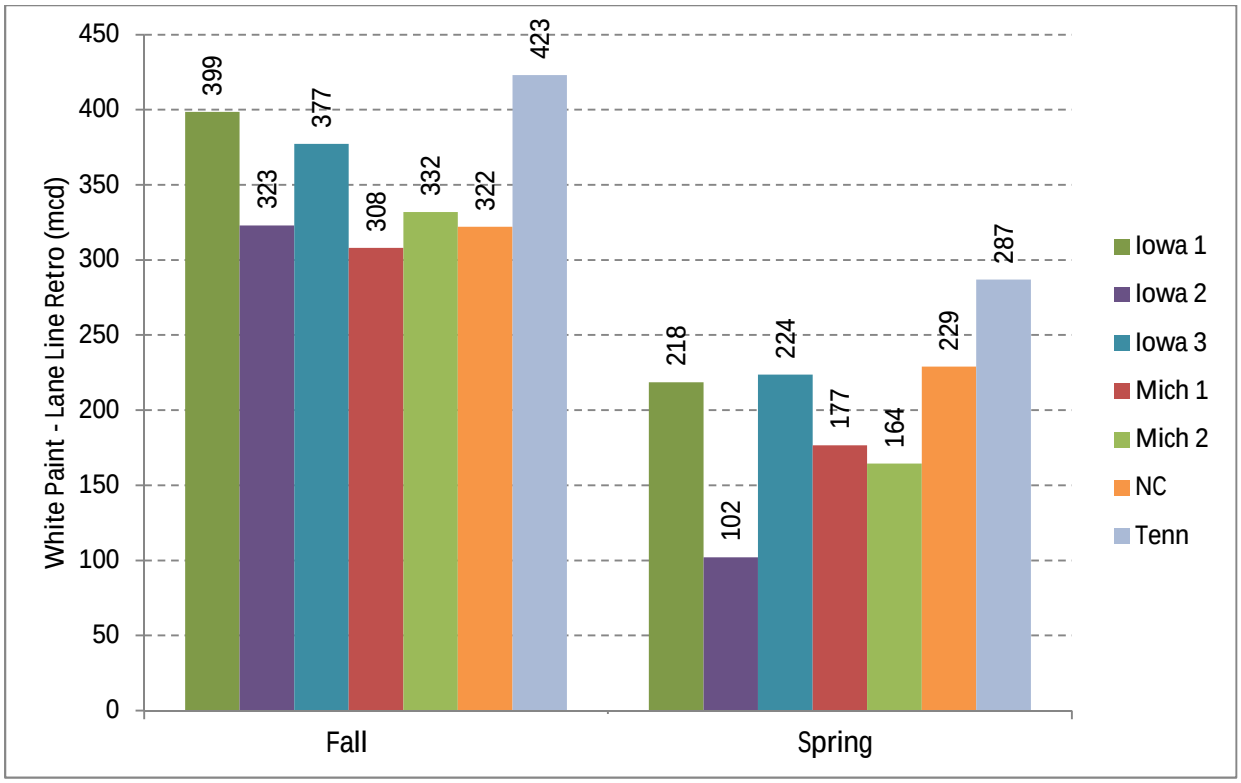

Figure 3. Fall and Spring Retroreflectivity Readings for White Paint on Lane Lines

The field data then were classified by Snow Belt and non-Snow Belt State in accordance to Table 1. The results are reported below in Table 3.

Table 3. Summary of Retroreflectiviy Loss (mcd)

	Pavement Marking Type	Fall Retroreflectivity	Spring Retroreflectivity	Loss in Retroreflectivity over Winter
Snow Belt States	White Edge Line	327	152	175
	Yellow Center Line	212	106	106
	White Lane Line	348	177	171
Non -Snow Belt States	White Edge Line	374	307	67
	Yellow Center Line	182	147	35
	White Lane Line	372	258	114

In both cases, the yellow center line pavement marking provides the lowest retroreflectivity levels before and after the winter months. It is interesting to note, however, that the yellow center line pavement markings lose the least amount of retroreflectivity.

Summary of Field Data

Of primary concern leading to this study was the condition of pavement markings in northern tier states after the winter months. Winter maintenance activities such as snow plowing and spreading sand for traction can seriously degrade pavement marking retroreflectivity.

Data from seven northern tier states show average white edge line retroreflectivity levels in the 300 +/- 50 mcd range before the winter months (for paint-based pavement markings with AASHTO M247 Type beads installed in the summer). After the winter months, the data show average white edge line retroreflectivity levels in the 150 +/- 50 mcd range, which is a reduction of approximately 50%. The same range of retroreflectivity levels were also reported for white lane line pavement markings after the winter months.

The average retroreflectivity levels of the yellow centerline pavement markings were mostly at or above 200 mcd before the winter months. While these pavement markings lost less retroreflectivity over the winter months than the white pavement markings, the retroreflectivity levels after the winter months were much lower, partly because their initial levels were lower. After the winter months, the average of the yellow centerline pavement markings was about 100 mcd. However, in three different cases, the average yellow centerline pavement marking retroreflectivity level after the winter months was less than 100 mcd, and in one case, only 30 mcd.

As expected, data from two states without significant winter maintenance activities show much less degradation during the winter months. The average retroreflectivity of white pavement markings after the winter months was over 250 mcd. However, the average retroreflectivity of yellow pavement markings after the winter months was just under 150 mcd.

NTPEP DATA

For this task, we compiled one year data collected through the National Transportation Product Evaluation Pavement Marking (NTPEP) test decks in Minnesota, Florida, and Pennsylvania. Appendix C is a summary of both state data received and NTPEP data . We used the data to investigate the following items of interest:

- Differences in performance between in the wheel track and out of the wheel track
- Differences in products performing at various levels of retroreflectivity
- Marking type, i.e. paint, thermoplastic, or tape
- Type, size, and quantity of glass beads, including the use of double drop beads

Wheel Track Data

For this analysis, we used the 3-year paint data because it was used in all three states and has more data than any other type of pavement marking material. We also performed this analysis by state because there is a consistent difference in the performance across the states. For instance, across all colors and pavement types, and for all three-year paint products, Florida experienced a decrease of about 70 mcd during the winter months while Minnesota had an overall loss of 175 mcd and Pennsylvania had the most loss of retroreflectivity, 216 mcd (all states had an average initial retroreflectivity between 339 and 310 mcd).

In Florida, the difference in performance between the wheel track and out of the wheel track is shown in Table 4 below. As expected, the wheel track data consistently experienced more degradation than outside of the wheel track.

Table 4. Florida 3-Year Paint Summary (First Winter)

Fall Retroreflectivity (mcd)	Spring Retroreflectivity (mcd)	Loss of Retroreflectivity (mcd)	Percent Loss	Condition
378.7	297.7	81.0	21%	W skip
380.5	281.3	99.2	26%	W wheel
241.0	203.6	37.4	16%	Y skip
239.8	178.9	60.9	25%	Y wheel

In Minnesota, the differences between performance in the wheel track and out of the wheel track is shown in Table 5. In terms of percent loss, the wear experienced in Minnesota is at least doubled that experienced in Florida. Like Florida, the wheel track data consistently experienced more degradation than outside of the wheel track.

Table 5. Minnesota 3-Year Paint Summary (First Winter)

Fall Retroreflectivity (mcd)	Spring Retroreflectivity (mcd)	Loss of Retroreflectivity (mcd)	Percent Loss	Condition
312.9	166.5	146.4	47%	W skip
315.0	132.7	182.3	58%	W wheel
308.9	123.6	185.3	60%	Y skip
308.5	120.5	188.0	61%	Y wheel

Table 6 includes the summary data from Pennsylvania, which shows the most wear. On average, about 65 percent of the initial performance was lost during the winter months. In Pennsylvania, the wheel track data experience a much greater amount of degradation than the data outside the wheel track. For both colors, the drop outside the wheel track was just over 50 percent while inside the wheel track the drop was over 80 percent.

Table 6. Pennsylvania 3-Year Paint Summary (First Winter)

Fall Retroreflectivity (mcd)	Spring Retroreflectivity (mcd)	Loss of Retroreflectivity (mcd)	Percent Loss	Condition
463.7	261.5	202.2	44%	W skip
388.2	96.0	292.1	75%	W wheel
279.2	105.7	173.5	62%	Y skip
224.4	29.8	194.7	87%	Y wheel

In addition to the wheel track comparison, the NTPEP data from Pennsylvania were compared to the field data from Pennsylvania (discussed in the previous section). The NTPEP fall retroreflectivity levels for both the white and yellow pavement marking materials were much higher than field retroreflectivity levels (for white the initial NTPEP data were about 200 mcd higher than the field data and for yellow the initial NTPEP data were about 100 mcd higher than the field data). After the winter months, the white NTPEP skip data were about 100 mcd higher than the field data. Interestingly though, after the winter months, the yellow NTPEP skip data were about the same as the field data. While the pavement marking materials used in practice in Pennsylvania are likely to be different than the NTPEP pavement marking materials used for this comparison, these results are similar to those in the previous section demonstrating difficulty of maintaining the retroreflective performance of yellow pavement markings above 100 mcd throughout a winter in northern tier states using paint (which most northern tier states use for most of the pavement markings).

Performance beyond One Year

In order to understand how general classes of pavement markings maintain their retroreflectivity beyond one winter in northern tier states, the NTPEP wheel track data from Pennsylvania and Minnesota were evaluated. Different manufacturer's products were grouped together using the binder type and the bead size. The data used here were from white pavement markings installed on asphalt.

Table 7. Performance of Pavement Markings in Pennsylvania

Pavement Marking Type	Retroreflective Optics	Fall Retroreflectivity (mcd)	Spring Retroreflectivity in Wheel Track (mcd)
2-YR waterborne	Type I	318.8	70.8
3-YR waterborne	Type I	423.7	133.1
Thermoplastic	Type I	377.7	150.0
Thermoplastic	Type I/IV	513.5	195.8
Preformed Thermoplastic	Varies	392.6	130.5
Epoxy	Type I	341.8	174.4
Epoxy	Type I/IV	368.6	223.0
Durable Tapes	Varies	373.8	75.9
MMA	Not reported	606.9	225.0
Modified Urethane & Polyurea	Type I	374.5	151.5
Modified Urethane & Polyurea	Type I/IV	486.2	197.4
All Weather Paint	Type I / multicomponent optic	304.6	52.5

There is not a known correlation between the wheel track data of NTPEP and actual performance on the roadway. Therefore, it is difficult to say how far beyond one winter the data shown in the last column of Table 7 might represent. Using the data available from this study, we used the following thought process to develop an estimate of performance beyond one year using the spring wheel track data of NTPEP.

From the comparison of white retroreflectivity levels outside the wheel track, a loss of about 200 mcd occurs during the first winter, which is about a loss of 50 percent loss. The same loss over the second winter, assuming the summer degradation is negligible, would put the total two-year percent loss at 75 percent, which is similar to the wheel track data from Pennsylvania. Therefore, based on the correlation described here, the spring data from the wheel track appear to represent two years of service in snow belt areas such as Pennsylvania. If so, there appear to be a number of durable pavement marking materials that will provide multiple year performance above 150 mcd.

As noted earlier, the retroreflectivity degradation experienced in Minnesota was less than seen in Pennsylvania; and the results shown in Table 8 are similar. In Minnesota, even the 3-year paint provides an average spring wheel track retroreflectivity above 150 mcd.

Table 8. Performance of Pavement Markings in Minnesota

Pavement Marking Type	Retroreflective Optics	Fall Retroreflectivity (mcd)	Spring Retroreflectivity in Wheel Track (mcd)
3-YR waterborne	Type I	324.8	151.0
Thermoplastic	Type I/IV	366.7	142.5
Preformed Thermoplastic	Varies	527.2	342.3
Epoxy	Type I / multicomponent optic	387.5	190.7
Durable Tapes	Varies	808.7	464.7
MMA	Type I/IV	872.2	444.5
Modified Urethane & Polyurea	Type I/IV	530.2	266.1

Size of Glass Beads

The Pennsylvania thermoplastic data were used for the analysis of size of glass. Minnesota only had double drop data and the data from Florida were suspect. For the Pennsylvania data, the product that used a double drop package (Type I and Type IV) did not install the same product with only Type I beads. Therefore, other manufacturers of thermoplastic using only a Type I optic were used for comparisons.

For all colors and pavement types, the double drop optics produced higher initial performance than the single drop Type I optic package (except the yellow concrete wheel path data). The initial benefit of the double drop optic package (assessed with the pre-winter data) ranged from 9 percent higher than single drop optic package to 111 percent higher, with retroreflectivity measurements above 600 mcd for some white markings. Overall, the increase in initial retroreflectivity performance using the double drop package was 61 percent.

After the winter months, the spring readings showed that the overall benefits of the double drop optics decreased to 11 percent (compared to the readings from the single drop applications). It is possible, and likely, that the double drop optics would have maintained their initial gains in performance through the winter months in Florida, where there is no snow-plow activity. Florida currently specifies a double drop application as their norm.

Bead Loading Rate

To evaluate the bead loading rate, we analyzed NTPEP data with at least 3 different bead loading rates. For Florida, we looked at the 3-year white waterborne paint. The reported loading rates were 6, 10, and 17.6 pounds of Type I beads per gallon of paint. The heavier bead loading rates included thicker applications of the waterborne paint (from 15 mil up to 25 mil). The Florida data from outside the wheel track is reported in Figure 4.

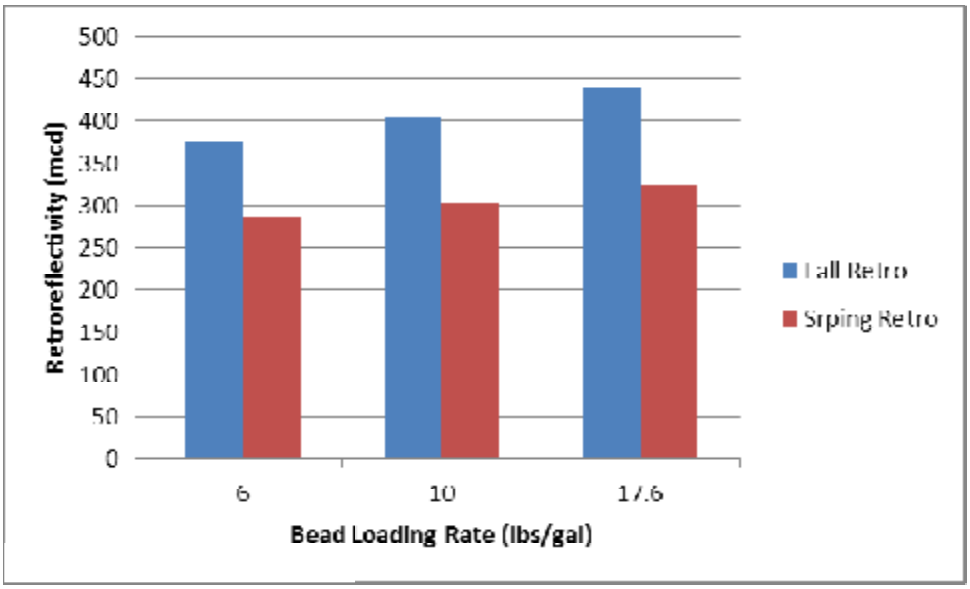

Figure 4. Effect of Quantity of Beads outside the Wheel Track in Florida

The loading rate consistently produced higher retroreflectivity levels, both initially and after the first winter. The loss of retroreflectivity also increased with loading rate. As shown in Figure 5, the same pavement markings produced less consistent results in the wheel track.

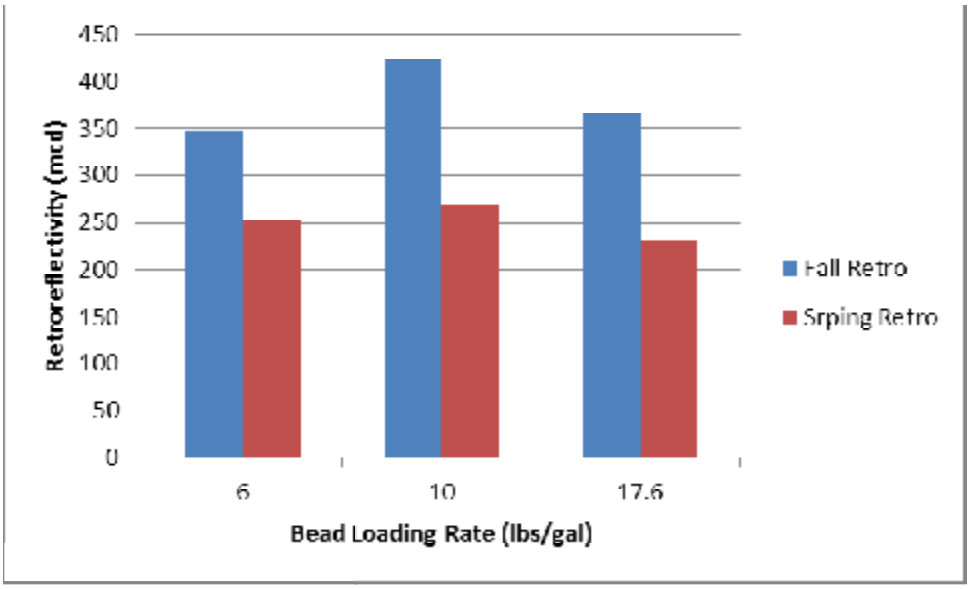

Figure 5. Effect of Quantity of Beads in the Wheel Track in Florida

We also evaluated the bead loading rate from 3-year white waterborne paint in Minnesota. In this case, the reported data implies that the loading rate was calculated from measurements of the weight of beads used. The data used in Figure 6 below are from outside the wheel track. Generally, there is no clearly evident pattern in the initial performance, but after the winter months it appears the heaviest bead loading rate, 9.3 pounds per gallon in this case, results in the highest post-winter retroreflectivity levels.

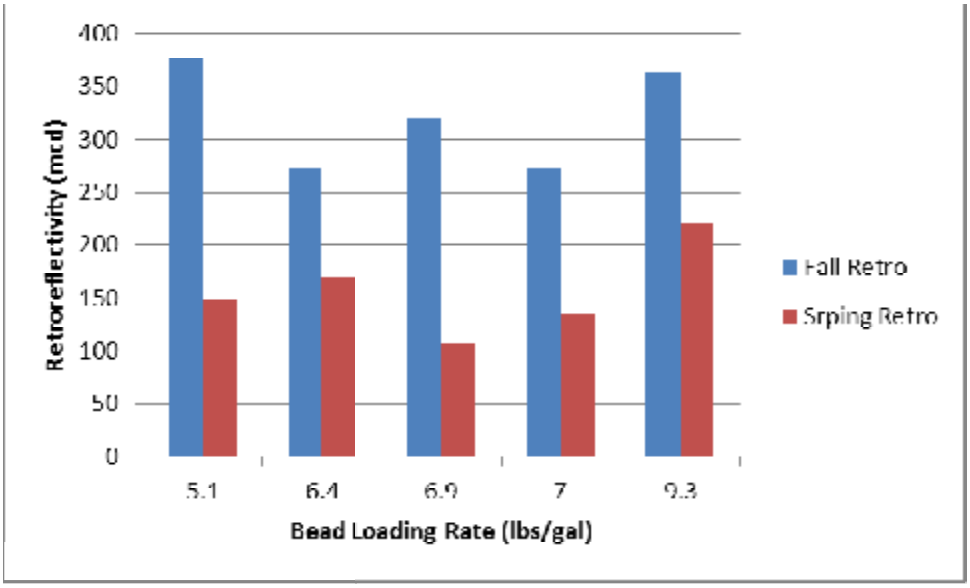

Figure 6. Effect of Quantity of Beads outside the Wheel Track in Minnesota

Figure 7 is from the same Minnesota pavement markings but include measurements in the wheel track. Again, the heaviest bead loading rate produced the highest post-winter retroreflectivity levels.

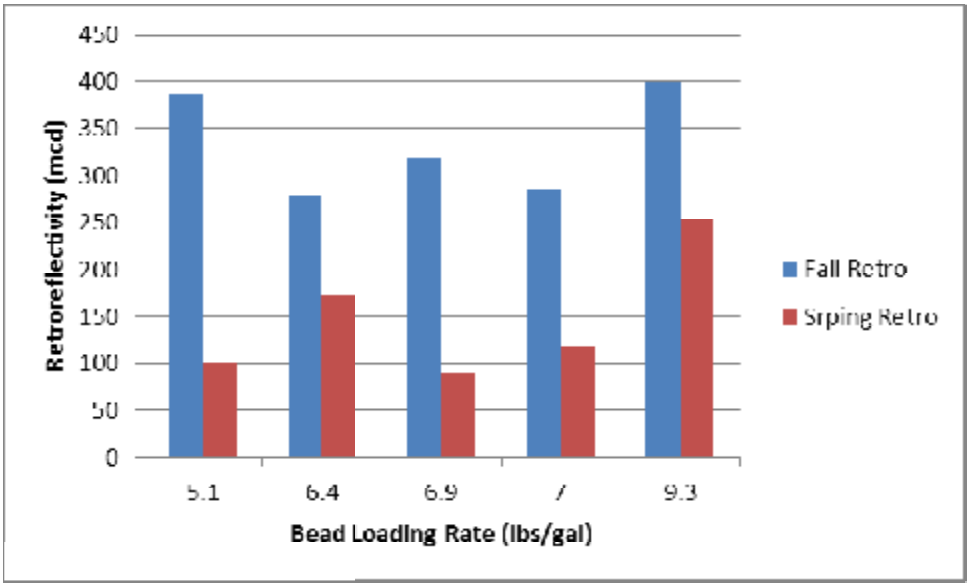

Figure 7. Effect of Quantity of Beads in the Wheel Track in Minnesota

The data were also evaluated from Pennsylvania but either too many unknown variables or the data appeared suspect. For instance, in Pennsylvania, where pavement markings were applied at loading rates as low as 4 pounds per gallon, the retroreflectivity was generally highest.

Summary of NTPEP Data

The NTPEP data were evaluated to add breadth to the study since the field data primarily addressed waterborne paint with Type I beads. Using Florida, Minnesota, and Pennsylvania NTPEP data, we explored differences in retroreflectivity data measured in the wheel track and outside the wheel track. This analysis was performed by state since there was a considerable difference in the amount of degradation experienced by state. Our results show that pavement marking retroreflectivity data from the wheel track are consistently lower than pavement marking retroreflectivity data outside the wheel track, indicating that the pavement markings experience more wear in the wheel track. As noted earlier, there is not an established correlation between the NTPEP wheel track data and actual field performance, but based on the data we estimated that the spring time retroreflectivity measurements from the NTPEP wheel track provide an estimate of expected performance at two years for snow belt states.

Like the field data, the NTPEP data, show difficulty of maintaining the retroreflective performance of yellow pavement markings above 100 mcd throughout a winter in northern tier states using paint (which most northern tier states use for most of the pavement markings).

For Minnesota and Pennsylvania, pavement marking types and optics were grouped together to evaluate the performance beyond one winter. Once again, we rely on our estimation that the NTPEP year 1 springtime wheel track results were equivalent of two years of performance. If so, there are a variety of durable pavement marking products (binder and beads) that can provide multiple years of maintained white retroreflectivity levels at or above 150 mcd.

Bead loading rates and bead size were also analyzed. For northern tiered states, there is evidence that each has a positive but small impact on maintained retroreflectivity levels through the winter months.

FINDINGS

The FHWA has started the rule-making process to add minimum pavement marking retroreflectivity requirements to the MUTCD. AASTHO and others are concerned about the difficulty in maintaining pavement marking retroreflectivity levels, especially in northern climates where winter maintenance activities tend to accelerate the degradation of pavement marking retroreflectivity.

Field data from 7 northern tier states show average white paint pavement marking retroreflectivity levels after the winter months in the 150 +/- 50 mcd range. Field data from the northern tier states show average yellow paint pavement marking retroreflectivity levels near 100 mcd with one state as low as 30 mcd. The field data lacked sufficient details concerning the type of roadway, speeds, and volumes, traffic mix, and snow plow events to further analyze the data.

Field data from two states without significant winter maintenance activities show much less degradation during the winter months. The average retroreflectivity of white pavement markings after the winter months was over 250 mcd. The average retroreflectivity of yellow pavement markings after the winter months was just under 150 mcd.

Test deck data from 3 states were also analyzed using the results of NTPEP. In Florida, the loss of retroreflectivity during the winter months was at most about 25 percent while in Pennsylvania the loss of retroreflectivity during the winter months as much as 62 percent outside the wheel track and 87 percent in the wheel track—further supporting the concern of northern tier states regarding maintained pavement marking retroreflectivity. A comparison of the field and NTPEP data for Pennsylvania cast doubt on whether higher initial retroreflectivity levels provide significantly higher springtime retroreflectivity levels in northern tier states such as Pennsylvania (at least for paint pavement markings with Type I optics).

For Minnesota and Pennsylvania, pavement marking types and optics were grouped together to evaluate the performance beyond one winter. It was estimated that the NTPEP year 1 springtime wheel track results were equivalent of two years of performance for northern tier states. If so, there are a variety of durable pavement marking products (binder and beads) that can provide multiple years of maintained white retroreflectivity levels at or above 150 mcd.

Bead loading rates and bead size were also analyzed. For northern tier states, there is evidence that each has a positive but small impact on maintained retroreflectivity levels through the winter months.

CONCLUSIONS

In their rule-making efforts of April 22, 2010, the FHWA proposed minimum retroreflectivity levels for longitudinal pavement markings (see Table 9). It should be noted that additional criteria were also included in the FHWA's proposal such as incorporating the center line and edge line warranting criteria of the MUTCD into the process of determining which roads and pavement markings need to be maintained.

Table 9. FHWA's Proposed Minimum Retroreflectivity Levels

	Posted Speed (mph)		
	≤ 30	35 – 50	≥ 55
Two-lane roads with centerline markings only ,	n/a	100	250
All other roads ,	n/a	50	100

- Measured at standard 30-m geometry in units of mcd/m^2/lux

, Exceptions:

A. When RRPMs supplement or substitute for a longitudinal line (see Section 3B.13 and 3B.14), minimum pavement marking retroreflectivity levels are not applicable as long as the RRPMs are maintained so that at least 3 are visible from any position along that line during nighttime conditions.

B. When continuous roadway lighting assures that the markings are visible, minimum pavement marking retroreflectivity levels are not applicable.

In August 2010, AASHTO submitted their comments to the FHWA proposed levels above. Table 10 shows AASHTO's recommendations in similar form to FHWA's proposal. AASHTO suggested lowering the retroreflectivity levels and adding third exception.

Table 10. AASHTO's Suggested Changes to FHWA's Proposed Minimum Retroreflectivity Levels

	Posted Speed (mph)		
	≤ 30	35 – 50	≥ 55
Two-lane roads with centerline markings only ,	n/a	80	100
All other roads ,	n/a	50	80

- Measured at standard 30-m geometry in units of mcd/m^2/lux

, Exceptions:

A. When RRPMs supplement or substitute for a longitudinal line (see Section 3B.13 and 3B.14), minimum pavement marking retroreflectivity levels are not applicable as long as the RRPMs are maintained so that at least 3 are visible from any position along that line during nighttime conditions.

B. When continuous roadway lighting assures that the markings are visible, minimum pavement marking retroreflectivity levels are not applicable.

C. When delineators are placed along the roadway according to Section 3F.04, minimum pavement marking retroreflectivity levels are not applicable.

In the summer of 2011, the AASHTO Subcommittee on Traffic Engineering (SCOTE) took additional action. The SCOTE drafted the following language and minimum retroreflectivity levels as an alternative to the MUTCD language that was being considered.

Standard:

Compliance shall be achieved by having a management method in place and using the method to attain the minimum initial application and minimum retention levels of the markings as shown below. Minimum initial application levels shall be met at the time the marking is placed on the roadway. Minimum retention levels shall be met until such time as natural or scheduled events (see Support) occur, which make it impossible to apply new markings.

Support:

Natural and scheduled events include, but are not limited to, winter weather, environmental conditions, reconstruction, pavement resurfacing, and localized or abnormal wear. These are factors for agencies to consider when developing a management method to maintain minimum pavement marking retroreflectivity.

	Posted Speed (mph)	
	35 – 50	≥ 55
Minimum Installation Levels	100	150
Minimum Retention Levels	50	75

Figure 8. AASHTO SCOTE's Alternate MUTCD Language

As reported earlier, the field data lacked sufficient details concerning the type of roadway, speeds, and volumes to make a direct comparison to the FHWA proposal minimum retroreflectivity levels. However, the field data provide evidence that the FHWA proposed minimum retroreflectivity levels appear too high to be practical, particularly for the higher speed classification (≥ 55 mph) and yellow pavement markings.

AASHTO's letter to the FHWA concerning their proposal makes recommendations for lower thresholds, but perhaps not low enough based on the results reported here. The latest AASHTO SCOTE recommendation contains a unique concept of using initial installation levels as part of the requirements. In the AASHTO SCOTE proposal, the initial installation levels are also combined with a set of retention levels.

Based on the initial levels reported in both the field data and the NTPEP data, the installation levels proposed by AASHTO SCOTE seem conservative for white pavement markings and reasonable for yellow markings. The retention levels proposed by the AASHTO SCOTE are probably the most reasonable of the

three sets of proposed minimum levels summarized in this report. However, according to the data reported herein, there would still be failure in northern tier states. For instance, the average yellow springtime retroreflectivity levels in two different states were less than 60 mcd. There may be room for improvement of these state's specifications, inspection practices, and management techniques. Table 11 lists a summary of the maintenance programs employed by each data that contributed field data.

Table 11. Brief Summary of State Pavement Marking Maintenance Programs

Tennessee	Uses enhanced thermo plastic in most of our new pavement applications. We also use some rumble stripes with widths that vary based on lane and shoulder width. We retrace lines with both paint and spray thermo depending on route type using a pay for performance contract model and acceptance at 45-75 days after application. Retracing is performed at varying intervals. We are hoping to achieve a 2 year life on our paint retracing, and 3 years on our spray thermo. We may not get to these lifetime due to heavy plowing or intense traffic locations.
Maine	Maine DOT's pavement marking maintenance is based on a "highway priority" rating system. That is, the Bureau of Transportation Systems Planning established a "grade" for each roadway for which we have a Level of Service 1 thru 6 (LOS) maintenance responsibilities. Naturally, the interstate LOS 1, US routes LOS 1&2 and other State Routed Highways LOS 2, 3, & 4 with the remainder of the minor collectors being LOS 5 and local roads a LOS 6 with no state responsibility for striping. While we attempt to get them done early in our season, the coastal highways are also done earlier, as tourism and fog play a role there. We do the northern piece of the interstate anytime during the season, but because we do the southern (180 miles or so) at night, we have to wait until July in order to have temperatures to dry the paint. All of these roads and the remainder of our routed roads are done annually. Edgeline is done bi-annually on most of the system.
North Carolina	North Carolina is striving to use the most cost effective long life markings by evaluating different pavement marking material life cycles with respect to the different facilities and surfaces they are used. In doing this, we are attempting to mitigate premature restriping and align pavement marking life cycles and roadway surface maintenance.
Pennsylvania	In its simplest terms, PennDOT's policy is to re-stripe every state-owned roadway once each year. With the exception of re-striping the Interstates twice a year when waterborne pavement marking materials are being used.
Michigan	We have an annual restriping program. Approximately 85% of our roads are restriped each year. The other 15% is under construction or has durable markings.
Iowa	The Iowa DOT's highway maintenance/operations activities are organized regionally. We have six districts, and each operates their own paint crews and equipment. Each district is responsible for somewhere between 3,700 to 4,600 lane-miles of the primary network. We are standardized to the extent that we use the same products (primarily regular waterborne paint, with "high build" paint used by some districts in heavy traffic areas), however the crews operate otherwise independently. We have a standardized measurement program for retroreflectivity on our network, and each of our six districts are able to use that information to prioritize their striping activities. We have standards for retroreflectivity both for our own forces as well as for any painting done by contractors (contractors are typically only used in construction/resurfacing projects). The minimum standards for our markings are 150 mcd/m^2/lux for white paint and 100 mcd/m^2/lux for yellow paint. When markings are measured below this threshold (or when their presence

	is considered to be "significantly" reduced), the markings are *scheduled* for repainting. Our pavement marking are mostly surface-applied, so winter maintenance operations usually lead to significant degradation. In an average year, our crews will re-stripe very close to 100% of the yellow dashed centerlines on the two-lane portion of our network and nearly 100% of the white dash skips on our expressways and freeways. Edge lines are typically painted every two years in a cycle, but depending on condition it might be more or less frequent. In some places the "high build" paint has allowed us to get two good years of out of our lines. Retroreflectivity readings are one factor in determining which edge lines to paint in a given year. Usually our striping activities are limited by budget and time (in Iowa we can only paint from mid-April to mid-October) and not by the needs of the system.
West Virginia	We have our District striping which is painted annually. Tested once during October. We have our 2 year Interstate and APD corridor jobs which are tested once in August and Sept of the year painted for initial reflectivity and then again the following spring or summer for reflectivity. If anything fails at anytime from the checks then the contractor has to repaint. We have recall striping for purchase order paving and touch up painting from DOH maintenance work. Not testing since these are small jobs. Let me know if you need anything else.
Wisconsin	Most of Wisconsin DOT's new or resurfaced pavements are first marked with epoxy. We typically restripe with epoxy one or two more times in approximately 4-year increments. This 4-year cycle is based on our experience with epoxy durability and a small sampling of retroreflectivity measurements. Epoxy restriping may occur more or less frequently depending on the condition of the marking. At some locations we will measure the retroreflectivity to determine when to restripe. After two restripings, or if the pavement condition has deteriorated, we would typically restripe with waterborne paint. Paint restriping is done annually as much as budget allows. Restriping of some edgeline marking on lower-volume highways is deferred for an additional year based on available funding. We are intending to collect additional retroreflectivity data to further support decisions on pavement marking life cycles and frequency of restriping.
New Hampshire	NHDOT maintains four long line pavement marking crews, using a combination of full time pavement marking personnel supplemented with temporary personnel for the paint season, in order to maintain all of our centerline and edgeline markings each summer. We use water borne paint specification. We have recently specified recessed durable markings, namely polyurea, for markings on divided highways. In addition, we maintain four intersection, or stencil marking, crews, two crews each for water borne and thermoplastic operations. Our annual production is estimated as the equivalent of 80,000,000 linear feet of 4' line.

RECOMMENDATIONS

Keeping the roadways safe under daytime and nighttime conditions is perhaps the most critical mission of any state highway agency. Being able to see the designated travel paths is obviously a key element to keeping the roadway safe. Retroreflective pavement markings are used to help nighttime drivers find and maintain their designated path. It is reasonable that retroreflective pavement markings have some minimum performance level to ensure they are doing their intended purpose. However, it is also important to understand the practicalities and limitation of pavement markings. For instance, pavement markings are installed using factories on wheels which introduce much variability to the quality of the installation. This variability is recognized and noted in various research reports also (11, 12). The quantities of pavement marking materials used are overwhelming and therefore low cost materials are used (e.g., over one billion pounds of recycled glass are used annually to make glass beads). In addition, in northern tier states, pavement markings take serious abuse from snow plow blades, sand and de-icing compounds, and even studded tires in some areas. Therefore, there is a practical limitation to the level of standard that can be expected concerning the maintenance of pavement marking retroreflectivity, particularly in northern tier states.

Consequently, based on the data summarized in this report, the following recommendations are provided for a minimum pavement marking retroreflectivity levels of longitudinal lines. These recommendations provide an option for agencies, based on their winter maintenance activities. An agency would be allowed to choose the most appropriate option for their conditions.

For agencies or areas with little or no snow plowing:

Minimum Maintained Retroreflectivity of Yellow Markings = 75 mcd

Minimum Maintained Retroreflectivity of White Markings = 100 mcd

For agencies or areas with consistent snow plowing activities and an annual restriping policy:

Minimum Installed Retroreflectivity of Yellow Markings = 175 mcd

Minimum Installed Retroreflectivity of White Markings = 250 mcd

For northern tier states that annually restripe most or all of their roadways, the concept of using initial minimum retroreflectivity levels may be a practical alternative to having to maintain a certain retroreflectivity level after the winter months. The initial minimum retroreflectivity can be set so that there is some assurance that a quality pavement marking was installed prior to winter. Agencies may elect to measure their markings in the fall to demonstrate they are in compliance; however, retroreflectivity levels in the early spring would be irrelevant from a compliance point of view. From the data reported here, it is not reasonable to expect waterborne pavement markings with Type I optics (the most commonly used materials in northern tier states with annual striping programs) to always maintain their retroreflectivity through the winter months. If agencies opt to use an initial minimum retroreflectivity level rather than the minimum maintained level, it would seem reasonable that they also have a process in place to restripe roadways as early as possible in the spring, rather than waiting

until late summer to restripe. Or course the details of such a program, such as when to begin restriping and when to have their restriping completed, would be the responsibility of the agency with jurisdiction.

Other criteria might also be applied such as a minimum volume threshold, variations based on posted or operating speed, exemptions or reductions with the presence of roadway lighting, and exemptions or reductions with the presence of other delineation devices such as RRPMs and roadside delineators (although this raises the issue about whether the performance of these devices needs to be specified).

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ABBREVIATIONS AND ACRONYMS

AASHTO – American Association of State Highway and Transportation Officials

ASTM – American Society for Testing and Materials

FHWA – Federal Highway Administration (US DOT)

mcd- Units of pavement marking retroreflectivity, which is more formally known as the coefficient of retroreflected luminance with the units mcd per square meter per lux

MUTCD – Manual on Uniform Traffic Control Devices

NCUTCD – National Committee on Uniform Traffic Control Devices

NTPEP – National Transportation Product Evaluation Program

PENNDOT – Pennsylvania Department of Transportation

SCOTE – AASHTO Subcommittee on Traffic Engineering

SOM – AASHTO Subcommittee on Materials

TRB – Transportation Research Board

APPENDIX A

FHWA NPA Rule-Making

Proposed Pavement Marking Retroreflectivity MUTCD Text

Add to Compliance Date Information in the Introduction to the MUTCD:

Section 3A.03 Maintaining Minimum Retroreflectivity of Longitudinal Pavement Markings—new section—from the effective date of the Final Rule for Revision 1 of the 2009 MUTCD:

- 4 years from date of Final Rule for implementation and continued use of a maintenance method that is designed to maintain pavement marking retroreflectivity at or above the established minimum levels; and
- 6 years from date of Final Rule for replacement of pavement markings that are identified using the maintenance method as failing to meet the established minimum levels.

Add new reference document to Section 1A.11:

Section 1A.11

"Summary of the MUTCD Pavement Marking Retroreflectivity Standard," Report No. FHWA-SA-10-015.

Section 3A.03 ~~Maintaining Minimum Pavement Marking Retroreflectivity [reserved section]~~
Maintaining Minimum Retroreflectivity of Longitudinal Pavement Markings

Standard:

Public agencies or officials having jurisdiction shall use a method designed to maintain retroreflectivity of the following white and yellow longitudinal pavement markings, at or above the minimum levels in Table 3A-1:

1. Center line markings on roads where they are required or recommended by Section 3B.01. This shall include any no-passing zone markings, longitudinal two-way left-turn lane markings, and yellow markings used to form flush medians on such roads.
2. Lane line markings on roads where they are required or recommended by Section 3B.04. This shall include any dotted lane lines, lane drop markings, and longitudinal preferential lane markings on such roads.

3. Edge line markings on roads where they are required or recommended by Section 3B.07. This shall include any channelizing lines delineating gores, divergences, or obstructions on such roads.
4. Any optional edge line markings that are used to qualify for the lower minimum retroreflectivity values in the “All other roads” row of Table 3A-1.

Table 3A-1 Minimum Maintained Retroreflectivity Levels • for Longitudinal Pavement Markings

	Posted Speed (mph)		
	≤ 30	35 – 50	≥ 55
Two-lane roads with centerline markings only ,	n/a	100	250
All other roads ,	n/a	50	100

- Measured at standard 30-m geometry in units of mcd/m^2/lux

, Exceptions:

C. When RRPMs supplement or substitute for a longitudinal line (see Section 3B.13 and 3B.14), minimum pavement marking retroreflectivity levels are not applicable as long as the RRPMs are maintained so that at least 3 are visible from any position along that line during nighttime conditions.
D. When continuous roadway lighting assures that the markings are visible, minimum pavement marking retroreflectivity levels are not applicable.

Support:

Compliance with the above Standard is achieved by having a method in place and using the method to maintain the minimum levels established in Table 3A-1. Provided that a method is being used, an agency or official having jurisdiction would be in compliance with the above Standard even if there are pavement markings that do not meet the minimum retroreflectivity levels at a particular location or at a particular point in time.

There are many factors for agencies to consider in developing a method of maintaining minimum pavement marking retroreflectivity including, but not limited to, winter weather, environmental conditions and pavement resurfacing.

Guidance:

Except for those pavement markings specifically identified in the Option below, one or more of the following methods, as described in the 2010 Edition of FHWA's "Summary of the MUTCD Pavement Marking Retroreflectivity Standard (see Section 1A.11)," should be used to maintain retroreflectivity of longitudinal pavement markings at or above the levels identified in Table 3A-1:

A. Calibrated Visual Nighttime Inspection – Prior to conducting a nighttime inspection from a moving vehicle and in conditions similar to nighttime field conditions, a trained inspector calibrates his eyes to pavement markings with known retroreflectivity levels at or above those in Table 3A-1. Pavement markings identified by the inspector to have retroreflectivity below the minimum levels are replaced.

B. Consistent Parameters Visual Nighttime Inspection –A trained inspector at least 60 years old conducts a nighttime inspection from a moving vehicle under parameters consistent with the

supporting research. Pavement markings identified by the inspector to have retroreflectivity below the minimum levels are replaced.

C. *Measured Retroreflectivity – Pavement marking retroreflectivity is measured using a retroreflectometer. Pavement markings with retroreflectivity levels below the minimums are replaced.*

D. *Service Life Based on Monitored Markings – Markings are replaced based on the monitored performance of similar in-service markings with similar placement characteristics. All pavement markings in a group/area/corridor are replaced when those in the representative monitored control set are near or at minimum retroreflectivity levels. The control set markings are monitored on a regular basis by the visual nighttime inspection method, the measured retroreflectivity method, or both.*

E. *Blanket Replacement – All pavement markings in a group/area/corridor or of a given type are replaced at specific intervals. The replacement interval is based on when the shortest-life material in that group/area/corridor approaches the minimum retroreflectivity level. The interval is also based on historical retroreflectivity data for that group/area/corridor.*

F. *Other Methods – Other methods developed based on engineering studies that determine when markings are to be replaced based on the minimum levels in Table 3A-1.*

Option:

Public agencies or officials having jurisdiction may exclude the following markings from their minimum pavement marking retroreflectivity maintenance method(s) and the minimum maintained pavement marking retroreflectivity levels, but not from any requirements in Section 3A.02 to be retroreflective.

A. Words, symbols, and arrows,

B. Crosswalks and other transverse markings,

C. Black markings used to enhance the contrast of pavement markings on a light colored pavement,

D. Diagonal or chevron markings within a neutral area of a flush median, shoulder, gore, divergence, or approach to an obstruction,

E. Dotted extension lines that extend a longitudinal line through an intersection or interchange area,

F. Curb markings,

G. Parking space markings, and

H. Shared use path markings

APPENDIX B

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO
THE VOICE OF TRANSPORTATION

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August 17, 2010

U.S. Department of Transportation
Documents Management Facility
1200 New Jersey Avenue, S.E.
Washington D.C. 20590

FHWA Docket No. FHWA-2009-0139

Re: AASHTO Comments and Recommendations of the Notice of Proposed Amendment; Federal Register, 23 CFR 655, FHWA Docket No. FHWA-2009-0139; RIN 2125-AF34; National Standards for Traffic Control Devices; the Manual on Uniform Traffic Control Devices for Streets and Highways; Maintaining Minimum Retroreflectivity of Longitudinal Pavement Markings.

Introduction:

The members of the American Association of State Highway and Transportation Officials (AASHTO) expresses our thanks to the Federal Highway Administration (FHWA) for the opportunity to provide comments on the proposed amendments to the Manual on Uniform Traffic Control Devices (MUTCD) as outlined in the above referenced Docket information. What follows is AASHTO's position on the Docket with comments and recommendations relating to the establishment of specific language and values for maintenance of those pavement markings.

On April 22, 2010, the FHWA published a Notice of Proposed Amendment (NPA) in the Federal Register containing specific levels of retroreflectivity on longitudinal pavement markings. On July 1, 2010, the National Committee on Uniform Traffic Control Devices (NCUTCD) took action on that specific language and the specific levels of retroreflectivity for longitudinal pavement markings. The following list of items contains AASHTO's comments and recommendations in regard to the NCUTCD actions, as well as other concerns.

Comments and Recommendations on NCUTCD Actions (from July 1, 2010):

1. Under Table I-2 Target Compliance Dates Established by the FHWA, Section 3A.03 Maintaining Minimum Retroreflectivity of Longitudinal Pavement Markings, please reference the phrase "*4 years from date of Final Rule for implementation and continued use of a maintenance method that is designed to maintain pavement marking retroreflectivity at or above the established minimum levels; and in six years from date of Final Rule for replacement of pavement markings that are identified using the maintenance method as failing to meet the established minimum values.*" This language was approved by the NCUTCD. AASHTO recommends the deletion of the phrase "... at or above the established minimum levels ..." from the four year compliance period language. This is because the NCUTCD acted to delete the phrase from the Standard in Section 3A.03.

2. In Section 3A.03, under the Standard, please reference the phrase *"Public agencies or officials having jurisdiction shall use a method designated to maintain retroreflectivity of the following white and yellow longitudinal pavement markings, at or above the minimum levels in Table 3A-1 ..."* The NCUTCD action deleted the words *"... at or above the minimum levels in Table 3A-1 ..."* AASHTO concurs with this action.

   Also, in Section 3A.03, under the Standard the preposition *"by"* is replaced with the phrase *"... as described in ..."* AASHTO agrees with this action by the NCUTCD.

   A sentence was added to the end of the Standard in Section 3A.03 *"Except for the optional edge line marking described in item #4, optional white and yellow longitudinal pavement markings are not subject to this Standard, but shall comply with the requirement of Section 3A.02."* AASHTO concurs with this action by the NCUTCD to insert this clarifying sentence.

   The first paragraph under the Support section should be moved to the Standards section and needs to be modified to read *"Compliance shall be achieved by having a method in place and using the method to maintain the recommended minimum levels established in Table 3A-1. Provided that a method is being used, an agency or official having jurisdiction shall be in compliance even if there are occurrences when pavement markings do not meet the minimum retroreflectivity levels at a particular point in time."* AASHTO strongly supports the action by NCUTCD to change this Support statement to a Standard statement. Inclusion of this language in the Standard reflects and recognizes the concerns by our northern tier states that occurrences, in particular seasonal restrictions, make it impossible to sustain the minimum levels continually.

3. The NCUTCD relocated the second Support paragraph to the first Support Paragraph and needs to be modified to read *"These occurrences include, but are not limited to, winter weather, environmental conditions, reconstruction, pavement surfacing, and localized or abnormal wear. These are additional factors for agencies to consider in developing a method to maintain minimum pavement marking retroreflectivity."* AASHTO concurs in this action to modify the Support statement and to relocate it under the Standard statement that notes these occurrences.

4. A new Guidance statement was approved by the NCUTCD: *"The method should be designated to maintain retroreflectivity of the white and yellow longitudinal marking described in items 1-4 of the preceding Standard at or above the minimum levels in Table 3A-1."* AASHTO concurs in the creation of this Guidance statement.

5. Table 3A-1 *"Minimum Maintained Retroreflectivity Levels for Longitudinal Pavement Markings"* was approved by the NCUTCD. AASHTO's Subcommittee on Traffic Engineering has proposed a research project entitled "A **Synthesis** of Pavement Marking Retroreflectivity Maintenance Practices." This project would produce actual measurement of in-service pavement marking retroreflectivity levels to compare with those minimums proposed by FHWA. AASHTO requests that FHWA delay issuance of the Final Rule until this six month synthesis project could be completed. It is further recommended that this be a collaborative effort with both FHWA and AASHTO participating. The results would allow agencies to truly understand how the proposed rule could impact their maintenance practices and budgets.
   If the issuance of the Final Rule cannot be delayed, AASHTO recommends the levels for two-lane roads with only centerline markings be modified to the following units. Under posted speed of 35 to 50 mph the value should be 80 mcd/m^2/lux and for >/= 55 the value should be 100 mcd/m^2/lux. For all other roads, AASHTO recommends 50

mcd/m^2/lux for medium speeds and 80 mcd/m^2/lux for higher speed facilities. Until the above mentioned research project can be completed and the appropriate conclusions drawn, AASHTO believes these slightly lower values provide states and other jurisdictions with a more reasonable expectation to attain safe roadway systems without the constant threat of liability for failing to maintain higher levels.

6. Added wording to the notes in Table 3A-1. The NCUTCD added *"… for clean and dry pavement markings …"* to clarify when the measurement of the markings should be taken, AASHTO concurs with this action.
7. Added a third note to Table 3A-1 which states *"When delineators are placed along the roadway according to Section 3F.04, minimum pavement marking retroreflectivity levels are not applicable."* AASHTO believes that a modification of the need to maintain the minimum levels should be considered when delineators are installed..

Other concerns:

8. The northern tier states are concerned with maintaining prescribed retroreflectivity levels during the winter months. Roadway maintenance activities such as snow plowing and placement of traction sand degrades the pavement markings at such time when replacement of the markings is impossible. Failure to maintain retroreflectivity under a structured measurement program introduces additional tort liability. States may be taking on inordinate risk they have no control over as a result.

9. There are general concerns regarding the costs of implementation. The first paragraph under the Guidance section indicates that one or more of the listed methods "… should be used to maintain retroreflectivity of longitudinal pavement markings …" which mandates that a structured program must be created to manage and document pavement marking retroreflectivity. This mandated program will require additional resources in order to minimize the risks associated with maintaining pavement marking retroreflectivity at a prescribed level. While the costs of implementing and administering a pavement marking retroreflectivity program is not viewed as an unfunded mandate, the states will have to be staffed and equipped to handle the increased management of their programs.

These are our comments, recommended changes and concerns related to this Docket. Thank you for your consideration.

Sincerely,

John Horsley
Executive Director

Enclosure

JH:mav