EVALUATION OF MNDOT'S SIGN REPLACEMENT METHOD

Prepared for the Minnesota Department of Transportation

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I. INTRODUCTION/PURPOSE

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) states that compliance with the sign retroreflectivity standard is achieved by implementation and continued use of an assessment or management method that is designed to maintain regulatory and warning sign retroreflectivity at or above the established minimum levels (see Paragraph 2, 2A.08). The compliance date for this standard is June 13, 2014. Types of signs other than regulatory or warning are to be added to an agency's management or assessment method as resources allow.

The MN MUTCD states that one or more of the following assessment or management methods should be used to maintain sign retroreflectivity: Visual Nighttime Inspection, Measured Sign Retroreflectivity, Expected Sign Life, Blanket Replacement, Control Signs, or Other Methods (see description in Section II).

MnDOT's current methods, as stated in the Traffic Engineering Manual (TEM), are Expected Sign Life (12 years for ASTM Type III sheeting and 15 years for Type IX and Type XI sheeting) as the primary method with periodic Visual Nighttime Inspection as the secondary method. The expected sign life of 12 and 15 years was chosen based upon manufacturer warranties plus a couple of years. The Maintenance Manual states that high intensity reflective sheeting has an expected life of 10 years. See Section III of this report for additional information on the existing sign maintenance practices and guidelines of the TEM and Maintenance Manual.

MnDOT sign inventory data suggests that the replacement of traffic signs is well behind schedule. Out of approximately 400,000 signs on the trunk highway system, the data shows that approximately 80,000 signs are older than the expected 12-year life cycle.

In addition, nationwide research suggests that the actual service life of signs, in terms of retroreflectivity, is longer than the periods set forth in the current guidelines. District staff have also reported removing signs on replacement projects that clearly have not reached their service life.

The purpose of this study is to gather and review nationwide research studies and internal MnDOT experience and, based on this information, to reevaluate MnDOT's current signing replacement schedule. Field testing is not a part of this study.

Another study is currently being conducted by the Local Road Research Board (LRRB) that will provide an in-depth look at the service life of signs and include field testing and measurement. That study is expected to take approximately two years to complete. In the meantime, MnDOT is confident that sign service life is longer than the current replacement policy states. They have therefore undertaken this study to analyze the risks and cost effectiveness of the currently available methods and recommend a method or methods that will effectively balance costs and risks. The recommendations presented in this report will need to be reevaluated when the results of the LRRB study are released. In addition, as this report reflects the current state of

sign manufacturing, fabrication, data collection, etc., the recommendations in this report should be reevaluated and possibly changed as technology and standards change.

It should be noted that this report refers to different types of sign sheeting throughout the document. The FHWA Traffic Sign Retroreflectivity Sheeting Identification Guide is provided in the Appendix.

II. METHODS TO MAINTAIN SIGN RETROREFLECTIVITY

The assessment or management methods that should be used to maintain sign retroreflectivity are described below:

Visual Nighttime Inspection – The retroreflectivity of an existing sign is assessed by a trained sign inspector conducting a visual inspection from a moving vehicle during nighttime conditions. Signs that are visually identified by the inspector to have retroreflectivity below the minimum levels should be replaced.

Measured Sign Retroreflectivity – Sign retroreflectivity is measured using a retroreflectometer. Signs with retroreflectivity below the minimum levels should be replaced.

Expected Sign Life – When signs are installed, the installation date is labeled or recorded so that the age of a sign is known. The age of the sign is compared with the expected sign life. The expected sign life is based on the experience of sign retroreflectivity degradation in a geographic area compared with the minimum levels. Signs older than the expected life should be replaced.

Blanket Replacement – All signs in an area/corridor, or of a given type, should be replaced at specified intervals. This eliminates the need to assess retroreflectivity or track the life of individual signs. The replacement interval is based on the expected sign life, compared with the minimum levels, for the shortest-life material used on the affected signs.

Control Signs – Replacement of signs in the field is based on the performance of a sample of control signs. The control signs might be a small sample located in a maintenance yard or a sample of signs in the field. The control signs are monitored to determine the end of retroreflective life for the associated signs. All field signs represented by the control sample should be replaced before the retroreflectivity levels of the control sample reach the minimum levels.

Other Methods – Other methods developed based on engineering studies can be used.

The task force developed lists, as shown in the following Tables 1 through 5, attempting to capture the positive attributes, negative attributes, and other considerations for each of the five specific methods. The “Other Methods,” being nonspecific, was not reviewed in this manner. Each list was not intended to be an all-inclusive list of the attributes or requirements of each method.

Table 1: Visual Nighttime Inspection Attributes

Positive Attributes	Negative Attributes	Other Considerations
Observe more than retroreflectivity	Inspector availability and/or interest	Inspectors need to be properly trained.
Safer with inspectors remaining in vehicle	Weather dependent	Agency procedures need to be followed consistently.
Consistency if using one person	Subjective, particularly if using multiple people	
More efficient	No formal training	
Real world aspect	Nighttime-only misses structure or vegetation issues.	
Opportunity to observe other roadway items such as raised pavement markers, pavement striping, delineators, and object markers	Funding overtime pay to conduct the inspections during the late evening or early-morning hours	
Advanced equipment or sophisticated computer programs are not required.	Time consuming	
Lowest level of sign replacement and sign waste.		
Least administrative and fiscal burden of all the methods		

Table 2: Measured Sign Retroreflectivity Attributes

Positive Attributes	Negative Attributes	Other Considerations
High confidence that retroreflectivity is documented accurately	Labor intensive (hand)	Agencies must decide if sign measurements are to be collected when the signs are washed or unwashed.
Provides the most direct means of monitoring the maintained retroreflectivity levels of signs	Contrast is not evaluated, which is particularly a concern for red signs	
Provides the most direct comparison of the sign's in-service retroreflectivity relative to the minimum maintained retroreflectivity levels	Not proven (mobile)	
Removes the subjective nature of visual nighttime inspections	Expensive	
Data collected throughout the years can provide sheeting material deterioration rates for localized conditions.	Safety of personnel	
Sign compliance can be thoroughly documented, and there is a minimal amount of waste because only failed signs are targeted for replacement.	Equipment maintenance	
Can obtain measurements during normal daytime work hours	Signs may be difficult to access because of physical barriers, sign height, and certain roadway conditions. Some measurements with handheld contact units can be difficult and time-consuming.	
	Dew, light rain, and moisture on a sign can impede the data collection process.	
	Units only account for retroreflectivity readings, and this method does not consider overall sign appearance and uniformity.	

Table 3: Expected Sign Life Attributes

Positive Attributes	Negative Attributes	Other Considerations
Have good inventory	Maintenance can't keep up	The actual retroreflectivity of a sign is not assessed - only the age of the sign is monitored.
One policy for all	Different ages along one corridor	
Simple	Replacement before service life is reached	
More efficient	Based on warranty rather than service life	
Manpower – Don't have to check everything every year	One policy for everyone: rural-urban, metro-outstate	
Good public feedback (practice, not policy)	Little data exists on how different types of sheeting deteriorate over time in a given climate.	
Get all signs on corridor to same age and standard	There are no definitive results relating orientation of the sign face (sun angle) to its deterioration rate.	
Can measure sign retroreflectivity at the end of the expected sign life to confirm if the sign estimate for that type of sign is accurate or not.		

Table 4: Blanket Signs Attributes

Positive Attributes	Negative Attributes	Other Considerations
Simple (no sign management)	Replace signs before needed	A need to determine the replacement cycles remains.
Flexibility (by type)	Routine daily inspection and maintenance is still needed.	
Statewide rather than district	Operating costs and additional sign installation labor can be higher than with other methods.	
Regular replacement cycles can help with planning, scheduling, and budgeting.	Replacement time depends upon the type of sign sheeting used.	
Sign inventory and management systems may not be necessary; however, they could provide support.	Retroreflectivity levels of signs are not measured, and opportunities are limited for capturing data that may be useful in adjusting expected sign lives, trigger points, or sign maintenance strategies.	
There is an ability to target certain sign types, such as placing a greater priority on STOP signs or removing all signs with non-prismatic sheeting		
Administrative costs are low.		

Table 5: Control Signs Attributes

Positive Attributes	Negative Attributes	Other Considerations
Can cover different directions, areas, etc.	Labor intensive?	
Real world	Subjective	
Maximum expected sign life	How to cover all situations	
Allows flexibility	What is sample size?	
Not nearly as labor intensive as taking retroreflectivity readings on every sign in an agency's jurisdiction	Not representative of all signs	
	Management of system	
	Performance measures	
	Doesn't address standards or structures	
	Agencies need to purchase or obtain a retroreflectometer.	
	Installing control signs, collecting measurements, and analyzing the data can be time-consuming and costly.	
	There is no guidance on the number or percentage of the population the sample represents, how often a new set of control signs should be established, or how often the control signs should be checked for their retroreflectivity levels and appearance.	
	This method requires continuous monitoring of control signs and regular upkeep.	

III. CURRENT MNDOT METHOD

The following guidelines for sign maintenance practice are included in the TEM:

"1. Recurring maintenance schedule

Each maintenance area is charged with implementing recurring sign maintenance. A recurring maintenance schedule should be developed using a maximum 12 year cycle for encapsulated lens sheeting and a 15 year cycle for VIP [Type IX] and DG3 [Type XI] sheeting (unless field performance studies coordinated by OTST staff determine otherwise). In order to monitor the performance of the retroreflective qualities of in place signs, each district should conduct periodic nighttime retroreflectivity observations. This review shall include all signs on Mn/DOT right-of-way facing traffic entering from local roads.

"2. Traffic sign management system

Each district is charged with developing and maintaining a field inventory in accordance with the statewide sign management system. The development of a comprehensive field record of all signs is vital to sound maintenance management practice and budgets.

"3. Missing or damaged signs

Mn/DOT is responsible for replacing all damaged or missing signs, except Logo signs, on the trunk highway system. Generally, STOP, YIELD, and DO NOT ENTER signs have the highest priority for replacement. These signs warrant weekend or overtime work for repair or replacement. Other signs should be evaluated on a case by case basis to determine relative priority. However, each district should develop a procedure for dealing with reports of damaged or missing signs to assure the prompt replacement of critical signs."

The following guidelines for sign replacement are included in the Maintenance Manual:

"It shall be the Area Maintenance Engineer's responsibility to decide whether signs should be replaced by maintenance personnel or by contract. Generally, overhead signs and large Type A signs are replaced by contract. The contract is initiated by the District and programmed based on available funding.

"The following guidelines apply to signs replaced by maintenance personnel, generally the ground mounted Type C and Type D signs:

"1. The periodic sign replacement program is based on a sign life expectancy of approximately ten years for high intensity reflective sheeting.

"Each maintenance area should be divided into ten sign replacement sub-divisions. The boundaries should be selected so that there is approximately the same number of signs in each sub-division. Depending upon the geographic layout of the maintenance area, the division may be controlled either by area or by route. By establishing a rotation program all highway signing would be reviewed for replacement approximately every ten years.

"2. Prior to each year's replacement program, the district traffic office should review each roadway scheduled for sign replacement that year. This should include both a daytime and a nighttime review. Additional signing, relocation of signing or removal of signing may be incorporated into the program at this time.

"3. The replacement program includes the use of the latest standards for sign design, dimensioning, mounting and roadway location.

"4. As each new sign is installed, the mounting should be checked for deterioration. Bent or excessively rusted posts should be replaced. A warning sticker, color coded for year of installation, is affixed to the back of each new sign. Old standard 'four-pound' posts should be removed. New mounting should be furnished in accordance with the [MnDOT TEM], Figures 6.5A, 6.5B, 6.6A, 6.6B, and 6.6C.

"5. Signs that have recently been replaced on the roads scheduled for sign replacement may be left as is, provided that they are still in like-new condition and conform to 3. and 4. above."

It was noted by the MnDOT task force members that the guidelines relating to the Expected Sign Life method are being followed, but that the guidelines relating to the Visual Nighttime Inspection method are not being followed. The Districts represented on the task force provided the following comments:

General: Expected sign life is 12 years, which equates to replacing about 8 percent of the signs every year. However, Districts have had a difficult time replacing signs at this pace.

The Expected Sign Life method places too much weight on sign warranty.

Labor, especially outstate, plus truck mileage are the biggest costs in regard to the potential for just-in-time sign replacement.

The majority of construction projects do not match with the timing of sign replacement schedules and corridors. This produces corridors with mixed ages of signs when signing is replaced or added as part of construction projects.

Should cheaper material be used in high traffic areas where signs are hit often and need replacement within the 12-year expected life? Type IV sheeting is a cheaper material used in Wisconsin at a cost of $1.16/SF versus a cost of $3.65/SF for Type XI sheeting.

D3: A pilot project examined retroreflectivity and determined that less than 1 percent did not meet retroreflectivity standards. Contrast appears to be a greater concern.

They could have years without any work.

D7: If a sign is greater than six years old when replacing signs on a corridor, that sign is also replaced.

STOP signs are replaced separately when necessary.

D8: No scheduled nighttime review.

Corridor sign replacement projects replace all signs that are five years and older.

Current sign guidelines are also reviewed to determine if every sign is still needed.

It is important to look at STOP signs on crossroads.

Metro: Corridor sign replacement projects replace all signs that are five years and older.

Specific positive and negative attributes of the current Expected Sign Life method were recorded and voted upon to determine which attributes were deemed most important. The results are below:

Positive Attributes

Get all signs on corridor to same age and standard (7 votes).

Simple (6 votes).

More efficient (6 votes).

Manpower – don't have to check everything every year (4 votes)

Have good inventory (1 vote).

One policy for all (0 votes).

Good public feedback (practice not policy) (0 votes).

Negative Attributes

Replacement before end of service life (9 votes).

Based on warranty rather than service life (6 votes).

One policy for everyone: rural-urban, metro-outstate (2 votes).

Maintenance can't keep up (0 votes).

Different ages along one corridor (0 votes).

IV. LITERATURE RESEARCH

The second revision of the 2003 Federal Manual on Uniform Traffic Control Devices (MUTCD), Section 2A.09, introduced language establishing minimum retroreflectivity levels that must be maintained for traffic signs and requiring the adoption of a sign assessment or management method to maintain those minimum levels. Revision 2 also established compliance dates for Section S1.09 (Maintaining Minimum Retroreflectivity). The 2005 MN MUTCD adopted this language in February 2008, including the compliance date of January 2012 for the establishment and implementation of a sign assessment or management method.

In June 2012, the FHWA adopted Revision 2 to the 2009 MUTCD, revising the standards and compliance dates. The standard was revised to include only regulatory and warning signs, and the compliance date was changed to June 2014. The 2011 MN MUTCD adopted this language as Revision 1 in July 2012.

Since the adoption of these requirements, a number of studies regarding assessing and managing sign retroreflectivity have been completed, designed to assist agencies in the selection of a method and to maximize expected sign life while minimizing costs.

Reviewing these studies provides assistance in the selection of a management method and the refinement of the details of that method. The research reviewed and a short summary of the research is presented in Table 6. It is important to note that several of these documents also contained research and summaries on the range of practice, thus providing detail and insight beyond that listed here.

Table 6: Literature Review Summary

Title and Author	Date	Summary
Practices to Manage Traffic Sign Retroreflectivity (NCHRP Synthesis 431) TTI – Ré and Carlson	2012	Purpose was to provide examples of effective and advantageous practices that illustrate how different types of agencies can meet the retroreflectivity requirements. Using published research, existing guidance and policy, and telephone surveys, the goal was to document current states of practice and provide assistance to other agencies exploring the various methods available to maintain sign retroreflectivity.
Traffic Sign Maintenance/Management Handbook (Report No. 2010RIC10, Version 1.1) CH2MHill	Oct. 2010	A best practices guide designed to assist agencies in maintaining traffic signs on their roadways. Also intended to help develop a technically sound set of policies and practices. A resource document only, this guide does not set standards, requirements, or mandates.
Retroreflectivity of Existing Signs in Pennsylvania McCormick Taylor, Inc.	April 2012	Initiated by the Pennsylvania Department of Transportation in response the MUTCD mandate of having a sign maintenance method for maintaining traffic sign retroreflectivity, the goal was to collect and analyze sign retroreflectivity measurements on a subset of PennDOT signs to better understand the service life of signs. The findings are to assist PennDOT in better determining when signs may need to be replaced.
Sign Retroreflectivity, A Minnesota Toolkit SRF Consulting Group	June 2010	Toolkit for local agencies with guidance on the FHWA's sign retroreflectivity requirements and resources including sample sign management programs and replacement schedules that can be used to meet the compliance deadlines. Focused primarily on the FHWA's deadline to establish and implement a sign assessment or management method to maintain minimum levels of sign retroreflectivity by January 2012.
The Current State of Research on the Long-Term Deterioration of Traffic Signs Brimley, Carlson	Feb. 2012	An examination of current research in regard to the long-term performance of sign sheeting products. Concludes that a controlled long-term study of the deterioration of traffic signs with respect to retroreflectivity and color is needed to provide agencies with the necessary information to select appropriate traffic sign products.
Analysis of Traffic Sign Asset Management Scenarios Harris, Rasdorf, Hummer, Yeom	2007 TRB Annual Meeting	Analysis of traffic sign retroreflectivity maintenance methods using a sign asset management simulation that evaluates annual maintenance cost per sign and percent of traffic signs not compliant with the proposed FHWA standard. Based on inspection and sign data gathered in the field.
Field Inspections for Sheet Sign Life Cycle Indiana Department of Transportation	Nov. 2010	Tested ground-mounted sheet signs at various colors, ages, and locations to obtain retroreflectivity and color measurements. The study was designed to help INDOT establish the life cycle for sheet signs.
Field Inspections for Panel Sign Life Cycle Indiana Department of Transportation	May 2010	Tested ground-mounted panel signs at various ages and locations to obtain retroreflectivity and color measurements. The study was designed to help INDOT establish the life cycle for panel signs.

The phone survey conducted during the study “Practices to Manage Traffic Sign Retroreflectivity” (NCHRP Synthesis 431) yielded the data shown in Table 7 regarding the implementation of methods by the 40 responding agencies:

Table 7: MUTCD Assessment and Management Method Usage

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

Reports covering the assessment/management method, the standard associated with the method, criteria considered in regard to the method, cost, and other considerations of several state DOTs were reviewed. The following text and Table 8 summarize the findings by report, followed by a general summary of all the reports reviewed.

INDOT Panel Sign Life Cycle Study. The method used was Expected Sign Life, with a standard of 20 years. To determine the standard, the panel signs in five districts at various ages (10 years or older) were selected and had their retroreflectivity measured by the district traffic engineers. This study refers to ground-mounted Type A and Type D green destination signs as “Panel Signs” and standard Type C signs as “Sheet Signs.”

INDOT Sheet Sign Life Cycle Study. The method used was Expected Sign Life, with a standard of 18 years. To determine the standard, sheet signs 12 years or older were selected in north and south areas by the district maintenance staff. Most of the signs in the study had Type III sheeting; however, there was a corridor with 10- to 11-year-old Type IV sheeting. Samples of all four colors (red, white, green, and yellow) were tested and retroreflectivity levels measured. This study refers to ground-mounted Type A and Type D green destination signs as “Panel Signs” and standard Type C signs as “Sheet Signs.”

NCHRP MoDOT Case Study. The method used was Visual Nighttime Inspection, which was conducted at least once per year in the spring or fall. Quality assurance checks were initiated to monitor the inspectors. An engineer would use a retroreflectometer to spot-check certain signs on random selected roadways. The quality assurance checks were a way to assess inspection consistency and provide inspectors with feedback.

MoDOT also created an advanced expected sign life system. The transition from the old system to the new system was reasonably straightforward and well organized. The new system offers a large number of management and organizational capabilities. It helps track vandalism and monitors sign quality to extend the life of valuable resources. The engineers can use the planning, scheduling, and budgeting tools to improve maintenance operations. Technicians in the field are able to quickly access a considerable amount of information to accelerate and simplify their tasks.

PennDOT Retroreflectivity Final Report. The method used was Expected Sign Life, with a standard of 15 years. To determine the standard, signs 10 years or older were measured using

an Optics RetroSign 4500 retroreflectometer and Delta Light. The research did not find a direct correlation between age and retroreflectivity.

The report referenced another document (Analysis of Traffic Sign Asset Management Scenarios - March 2007) that analyzed 30 scenarios for the North Carolina DOT. NCDOT maintains over one million signs on its roadways. The findings included the following annual costs per sign: $3.43 to $5.24 for Visual Nighttime Inspection, $4.50 to $7.18 for Measured Sign Retroreflectivity, $5.09 for Expected Sign Life, and $6.22 for Blanket Replacement.

PennDOT Retroreflectivity Survey Results

Vermont DOT. The methods used were Expected Sign Life and Control Signs, with a standard of 15-20 years. A 15-year life cycle was used for small signs (<=20 SF), based on research study conducted in-house. A 15-year life cycle was used for large red signs (> 20 SF), and 15-20-year life cycle was used for large (>20 SF) green, white, and yellow signs. The sample size consisted of 618 signs.

Wisconsin DOT. The methods used were Expected Sign Life and Blanket Replacement, and the standard was a 12-year replacement cycle, based on their experience. The Wisconsin DOT has a control signs test deck, where signs face south to get maximum sunlight and UV rays.

Ohio DOT. The method used was Blanket Replacement, with a standard of 15 years. To determine the standard, the Oklahoma DOT Sign Life Study was used. Using simple statistical analysis, the study also determined that there is a high probability that signs of all colors 16 to 18 years old will continue to exceed minimum retroreflectivity levels.

Table 8: Summary of Methods and Standards

	Study/Report						
	INDOT Panel Sign* Life Cycle Study	INDOT Sheet Sign* Life Cycle Study	NCHRP MoDOT Case Study	PennDOT Retroreflectivity Final Report	PennDOT Retroreflectivity Survey Results		
					Vermont DOT	Wisconsin DOT	Ohio DOT
Method	Expected Sign Life	Expected Sign Life	Visual Nighttime Inspection (3)	Expected Sign Life	Expected Sign Life/Control Signs	Expected Sign Life/Blanket Replacement	Blanket Replacement
Standard	20 years	18 years	Conducted at least once per year (spring or fall)	15 years	15-20 years	12 years	15 years
Criteria Considered							
Location	No	No	No	No	No	No	No
Color	No	No	No	No	Yes (9)	No	No
Material	No	No	No	No	No	No	No
Multiple Sign Assemblies	No	No	No	No	No	No	No
Other	No	No	No	No	Yes (9)	No	No
Determination of Standard	Measured Sign Retroreflectivity (1)	Measured Sign Retroreflectivity (2)	None	Measured Sign Retroreflectivity (6)	Measured Sign Retroreflectivity	Measured Sign Retroreflectivity (10)	Oklahoma DOT Sign Life Study (11)
Method Establishment	NA	NA	(4)	NA	NA	NA	NA
Costs							
Method Implementation	NA	NA	NA	(7)	NA	NA	NA
Sign Installation	NA	NA	NA	NA	NA	NA	NA
Conclusions	NA	NA	Streamlines sign replacement and maintenance (5)	(8)	NA	NA	NA

The following is a summary of all of the studies outlined above:

- Most of the DOTs use the Expected Sign Life method, with an expected sign life of at least 15 years.
- Field-measured sign retroreflectivity was the predominant technique used to establish the expected sign life.
- In most of the studies, Type III sheeting was evaluated.
- Location, different material types, and assemblies with multiple signs were not factors in setting the standard.
- Costs were not evaluated in most of the studies.

V. METHOD SELECTION

Following discussion of the previous studies and their findings, the MnDOT task force members determined that the following attributes regarding the methods to assess and manage sign retroreflectivity were the most important:

- Maximizes expected sign life
- Simple
- Provides consistency of sign age and standards along a corridor
- Allows for effective planning, scheduling, and budgeting
- Administrative, engineering, and labor costs
- Efficient
- Flexible

Then, the MnDOT task force members voted on whether each of the five specific methods would have (positive vote) or would not have (negative vote) the particular attribute. In some cases, a member determined that an attribute was neither positively nor negatively reflected in a method. Thus, the number of votes was not consistent. The results of the voting are shown in Table 9.

Table 9: Method Attribute Voting Results

Attribute	Expected Sign Life		Visual Nighttime Inspection		Measured Sign Retroreflectivity		Blanket Replacement		Control Signs	
	Pos. Votes	Neg. Votes	Pos. Votes	Neg. Votes	Pos. Votes	Neg. Votes	Pos. Votes	Neg. Votes	Pos. Votes	Neg. Votes
Maximizes expected sign life	0	8	9	0	8	0	0	9	5	0
Simple	9	0	4	1	1	6	8	1	1	4
Provides consistency	6	3	1	4	2	3	9	0	5	0
Allows for effective planning	9	0	1	4	0	5	8	0	3	3
Costs	4	2	3	2	0	8	7	1	4	2
Efficient	8	1	2	4	1	7	7	0	3	4
Flexible	1	7	9	0	4	4	1	7	7	2
Totals	37	21	29	15	16	33	40	18	28	15

The voting results were used to guide the discussion in the selection of a traffic sign management method. The Measured Sign Retroreflectivity method was dismissed first due to the high number of negative votes. The remaining four specific methods all had a net positive in terms of votes, but no one method presented a clear enough advantage for its selection. Based on the voting results' mixed message, it was determined that a combination of methods may be the best option.

Once consensus was formed on using a combination of methods, Blanket Replacement and Control Signs were rejected as potential primary options. While Blanket Replacement had the highest number of positive votes in terms of key attributes, a procedure on how to team it with another method could not be determined. Control Signs seemed workable at first, but quickly became more complicated as exact details (such as the number of signs needed per year, the number of signs per fabricator, and recordkeeping needs) were discussed. Expected Sign Life was eventually settled upon as the primary method. This method has a familiarity and comfort level due to its use in the current policy and has strengths in five of the seven key attributes. To offset the weaknesses of this primary method in terms of maximizing expected sign life and providing flexibility, a need for a secondary method was recognized.

Initially, Visual Nighttime Inspection and Measured Sign Retroreflectivity were considered for the secondary method. However, further discussion identified limitations in evaluating retroreflectivity only. Research documents and the field experience of task force members indicated that signs often meet retroreflectivity standards longer than the sign color is able to maintain a satisfactory color contrast. In particular, it was noted that the red color in some stop signs has faded to white, yet the retroreflectivity increased.

Task force members then developed a secondary method of Visual Inspection, which is a combination of nighttime and daytime sign inspections. By committing to nighttime and daytime inspections, the retroreflectivity can be reviewed along with the color contrast. Other benefits associated with adding daytime inspection include the opportunity to review vegetation growth around the sign, the sign's structural integrity, and other engineering issues. For these reasons, Visual Inspection was selected as the secondary method. Although not one of the specific methods listed in the MN MUTCD, Visual Inspection is allowed under the Other Methods category. The research, discussion, and this resulting report are the engineering study required to use a nonspecified method under the Other Methods category.

Based on the research reviewed and the task force members' professional knowledge and field experience, the minimum expected sign life for all traffic signs was set at 15 years. This matches the current policy for Type IX and Type XI sheeting and is only slightly above the current 12-year policy for Type III sheeting. When a sign reaches the minimum expected sign life of 15 years, implementation of the secondary method is triggered to identify when the sign is at or near the minimum retroreflectivity levels and replacement is needed. Thus, the secondary method is able to extend the expected sign life beyond the minimum.

Recognizing the need for reengineering, no sign should remain in service indefinitely, even if retroreflectivity values remain above the minimum values. The importance of a maximum expected sign life was therefore established. Once the secondary method is initiated after the minimum expected sign life is reached, the sign could remain in service until the maximum expected sign life is reached and replacement becomes automatic. The maximum expected sign life was set at 20 years for Type IV sheeting and 30 years for Type IX or XI sheeting. Again, these parameters were set based upon the available research reviewed and the knowledge and comfort level of the task force members.

A Microsoft Excel spreadsheet was then developed to compare estimated annual costs. To be useful in evaluating costs in the future, the spreadsheet included a variety of inputs that can be changed as additional sign data is determined or updated. Some of these inputs include:

- Existing sign inventory. Based on data from the task force members, the approximate percentage of Type IV signs is 17% and the approximate percentage of Type IX or XI signs is 83%. Similarly, task force members provided the existing sign inventory data on each color of signs (in regard to the sign background): red (8%), green (14%), yellow (19%), white (34%), or other (25%).

- Base failure rate per year. Each type of sign and color of sign has a small percentage that fail each year due to factors and circumstances not related to age. An assumption of 8% per year for each sign type and color was made for the purposes of this report based on data from other research.

- Sign fabrication and installation cost per year. An assumption of $200 per sign, regardless of type or color, was made for the purposes of this report based upon MnDOT's in-house costs and contractors' costs for recent corridor sign replacement projects.

- Inspection rate. Prior research suggests that 40 to 200 signs per hour can be reviewed during a visual inspection. To present a conservative cost estimate, the lower rate of 40 signs per hour was used. Research also suggests that 8.3 signs per hour can be reviewed with a handheld retroreflectometer.

- Labor rate. Task force members recommended assuming a labor rate of $45 per hour for use in this study.

In addition to these evaluation inputs, the spreadsheet allows for testing different minimum or maximum expected service lives. If a range of expected service lives are used, the number of inspections (such as every year or once every five years) can be tested. Since these inputs and method factors can be adjusted within the spreadsheet, different options can be evaluated and compared in terms of the expected annual cost.

The spreadsheet assumes a fully implemented method rather than a program in its first years when all signs are new. The costs of recordkeeping and a sign database were not included, as any method will need some type of tracking system and the costs were assumed to be similar for each method.

Starting with the current implementation of the existing policy, the expected sign life (12 and 15 years depending upon the sheeting) was input into the spreadsheet. Assuming the level of effort needed for full implementation of this method, approximately 27,250 signs would be replaced each year, at an annual cost of approximately $5.45 million.

The number of signs that would be replaced and the annual costs for five other evaluation methods were then estimated for comparison with the existing policy. The five other methods were:

- Expected Sign Life of 15 years for all sign sheeting
- Expected Sign Life with Visual Inspection (the preferred primary and secondary methods as described earlier)
- Expected Sign Life with Measured Retroreflectivity
- Expected Sign Life with Control Signs (using Visual Inspection for evaluation of the control signs)
- Expected Sign Life with Control Signs (using Measured Retroreflectivity for evaluation of the control signs)

Table 10 shows the estimated number of signs that would be replaced annually and the estimated annual costs for each method.

Table 10: Sign Replacement and Annual Cost

Method	Estimated Number of Signs Replaced Annually	Estimated Annual Cost
Current Implementation – Expected Sign Life (12/15 Years)	27,244	$5,448,800
Expected Sign Life (15 Years)	26,133	$5,226,667
Expected Sign Life With Visual Inspection	14,177	$2,939,104
Expected Sign Life With Measured Retroreflectivity	14,177	$3,341,335
Expected Sign Life With Control Signs (Using Visual Inspection)	21,266	$4,262,063
Expected Sign Life with Control Signs (Using Measured Retroreflectivity)	21,266	$4,296,068

As shown, all options tested resulted in fewer signs replaced each year and a lower estimated cost than the current policy. Expected Sign Life with Visual Inspection resulted in the lowest number of signs replaced and the lowest estimated annual cost. Options using Measured Retroreflectivity showed comparatively higher costs than those using Visual Inspection due to the increase in labor costs.

The cost estimates developed assume an individual inspection of each sign once the minimum expected sign life is reached. When a sign is identified as not meeting the minimum retroreflectivity levels, the individual sign is then replaced. Through discussion of this assumption, it was recognized that the service life of each individual sign would be maximized. However, this approach could also result in a corridor with signs of multiple ages. The benefit of replacing individual signs is further offset by the additional cost in labor, traffic control, and fuel for that replacement. Recognizing both positive and negative aspects to individual sign replacement, corridor replacement may be a preferred method by some Districts or in specific instances.

These estimated costs are highly dependent upon the assumptions and inputs of the spreadsheet. Changes to the inputs or the assumptions, based upon new research, additional experience, or further method testing, will alter the results.

VI. FINAL RECOMMENDATIONS

The consensus of the task force, after considering the attributes of the five specific assessment or management methods, was to use the Expected Sign Life method as the primary method, with the establishment of minimum and maximum expected sign lives. The task force settled upon a visual inspection as the secondary method. The secondary method will commence when the minimum expected sign life is reached. This combination of methods will provide an acceptable balance between costs and risks.

It should be noted that the Visual Inspection method is not one of the five specific assessment or management methods listed in the MN MUTCD. It is, however, allowed as an Other Method, developed as the result of this engineering study.

Minimum and maximum expected sign lives were established as follows:

Minimum Expected Sign Life: 15 years

Maximum Expected Sign Life

- Type IV Sheeting 20 years
- Type IX or XI Sheeting 30 years

A sign can remain in service until its maximum expected sign life if a visual inspection indicates that the sign meets minimum retroreflectivity levels, including contrast. The visual inspection shall be used at the following sign ages:

Type IV Sheeting 15 and 18 years

Type IX or XI Sheeting 15, 18, and 20 years, and yearly thereafter

Non-prismatic sheeting should be inventoried and evaluated for action.

Each District shall develop a process for completing the visual inspection and appropriate documentation. Visual inspection shall consist of nighttime and/or daytime reviews. As a sign ages, the nighttime inspection becomes increasingly important. The visual inspection should also consider structural integrity, contrast, vegetation or other visibility issues, and/or

engineering issues. The FHWA provides guidance that may be incorporated into the nighttime inspection.

Engineering judgment may be used to replace signs with specific characteristics outside of the above guidelines (such as color, type, facing direction, mandates, etc.) through blanket replacement.

Due to the cost of labor, traffic control, and fuel for individual sign replacement, Districts may prefer to replace signs by corridor.

All information regarding sign maintenance, replacement, and management will be located in the TEM. The Maintenance Manual will include a reference to this information and the location in the TEM where it can be found.

VII. NEXT STEPS

The following work will be undertaken by the Traffic Engineering Organization (TEO) Signing Committee:

- Define visual inspection methods and processes.
- Determine any documentation measures for the new methods and how the transition to the new methods will be handled.
- Determine a process to correct/update sheeting types and sign panel ages in Sign Track.
- Recommend the minimum age of a sign to be replaced under a corridor sign replacement project.
- Develop an action plan for replacing signs with non-prismatic sheeting.

The State Sign Inventory and Management (SIM) Committee will reevaluate statewide performance measures based on this policy.

VIII. FUTURE CONSIDERATIONS

The sign replacement schedule and methods shall be reassessed when data is available from any of the following sources:

- National research
- MnDOT Materials Unit research at the MnROAD facility
- Local Road Research Board (LRRB) final report

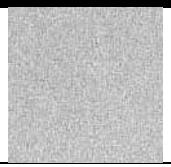
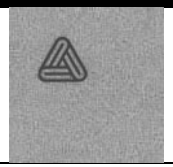
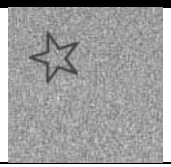
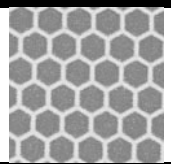
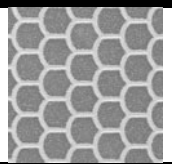
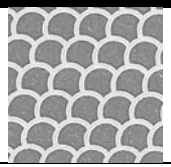
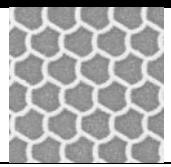
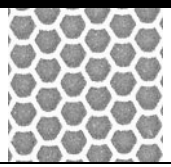
APPENDIX

2011 Traffic Sign Retroreflective Sheeting Identification Guide

U.S. Department of Transportation
Federal Highway Administration

This document is intended to help identify sign sheeting materials for rigid signs and their common specification designations. It is not a qualified product list. FHWA does not endorse or approve sign sheeting materials. Many other sheeting materials not listed here are available for delineation and construction/work zone uses.

Retroreflective Sheeting Materials Made with Glass Beads

Example of Sheeting (Shown to scale)								
ASTM D4956-04	I	II	II	III	III	III	III	III
ASTM D4956-09	I	II	II	III	III	III	III	III
AASHTO M268-10	(1)	(1)	(1)	A	A	A	A	A
Manufacturer	Several companies	Avery Dennison®	Nippon Carbide	3M™	ATSM, Inc.	Avery Dennison®	Nippon Carbide	Oracal
Brand Name	Engineer Grade	Super Engr Grade	Super Engr Grade	High Intensity	High Intensity	High Intensity	High Intensity	High Intensity
Series	Several	T-2000	15000	2800 3800	ATSM HI	T-5500	N500	5800
NOTES:	(2)	(3) (4)	(4)	(3) (4)	(4)	(4)	(4)	(4)

(1) – Sheeting material does not meet minimum AASHTO classification criteria.
(2) – Glass Bead Engineer Grade sheeting is uniform without any patterns or identifying marks. Section 2A.08 of the 2009 MUTCD (http://mutcd.fhwa.dot.gov) does not allow this sheeting type to be used for new yellow or orange signs, or new legends on green signs.
(3) – Material no longer sold in the United States as of the date of this publication.
(4) – Section 2A.08 of the 2009 MUTCD (http://mutcd.fhwa.dot.gov) does not allow this sheeting type to be used for new legends on green overhead signs.

- ASTM D4956-04 is referenced in Table 2A-3 of the 2009 MUTCD.
- ASTM D4956-09 is the most current ASTM sign sheeting specification (the 2009 version is designated by "-09").
- AASHTO M268-10 Types for this Guide are based only on retroreflective properties and not other unique AASHTO requirements such as color.

Manufacturer Contact Information

3M - http://www.3M.com/tss
Avery Dennison - http://www.reflectives.averydennison.com
Oracal - http://www.oracal.com
ATSM, Inc. - http://www.atsminc.com
Nippon Carbide - http://www.nikkalite.com
Reflexite - http://www.reflexite.com

FHWA Publication Number: FHWA-SA-11-14. For additional copies of this document, please send request to report.center@dot.gov

2011 Traffic Sign Retroreflective Sheeting Identification Guide

U.S. Department of Transportation
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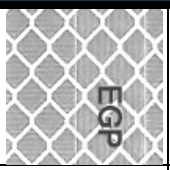
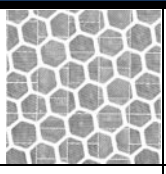
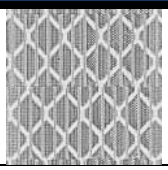
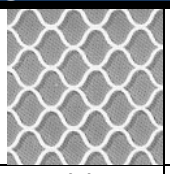
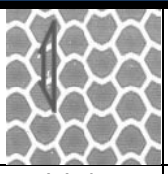
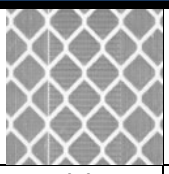
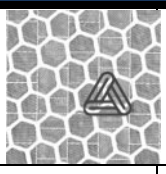
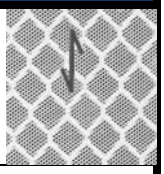
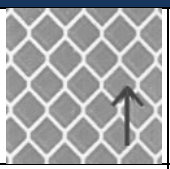
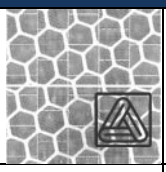
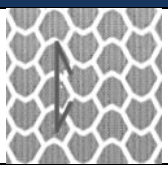
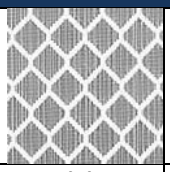
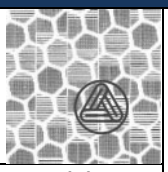
This document is intended to help identify sign sheeting materials for rigid signs and their common specification designations. It is not a qualified product list. FHWA does not endorse or approve sign sheeting materials. Many other sheeting materials not listed here are available for delineation and construction/work zone uses.

Retroreflective Sheeting Materials Made with Prisms

Example of Sheeting (Shown to scale)								
D4956-04	(5)	III, IV	III, IV, X	(5)	(5) / X	(5)	VIII	VII, VIII, X
D4956-09	I	III, IV	III, IV	IV	IV / VIII	VIII	VIII	VIII
M268-10	(6)	B	B	B	B	B	B	(9)
Manufacturer	3M™	Avery Dennison®	3M™	Reflexite®	Nippon Carbide	3M™	Avery Dennison®	3M™
Brand Name	Engr Grade Prismatic	High Intensity Prismatic	High Intensity Prismatic	High Intensity Prismatic	Crystal Grade	Reflective Sheeting	MVP Prismatic	Diamond Grade™ LDP
Series	3430	T-6500	3930	IC400	94000 / 92000	3940	T-7500	3970
NOTES:	(7)				(8)			(10)

Example of Sheeting (Shown to scale)					
D4956-04	IX	IX	(5)	(5)	(5)
D4956-09	IX	IX	IX	XI	XI
M268-10	B	B	B	D	D
Manufacturer	3M™	Avery Dennison®	Nippon Carbide	3M™	Avery Dennison®
Brand Name	Diamond Grade™ VIP	OmniView™	Crystal Grade	Diamond Grade™ DG3	OmniCube™
Series	3990	T-9500	95000	4000	T-11500
NOTES:					

NOTE: The watermarks have been enhanced in this ID Guide. They are shown to scale but are not as visible on actual sheeting materials. It helps to view the sheeting materials at different angles to see the watermarks. The spacing of the watermarks varies and therefore watermarks may not be present on small pieces of sheeting.

(5) – Material was either unavailable in 2005 (previous version of this Guide) or unassigned in the 2004 version of ASTM D4956.
(6) – Sheeting material does not meet minimum AASHTO classification criteria.
(7) – Section 2A.08 of the 2009 MUTCD (http://mutcd.fhwa.dot.gov) does not allow this sheeting type to be used for new yellow or orange signs, or new legends on green signs.
(8) – These two materials (94000 and 92000) are visually indistinguishable from one another.
(9) – Material has been discontinued prior to AASHTO M268-10.
(10) – Material no longer sold in the United States as of the date of this publication.

Resources

Federal Highway Administration – http://www.fhwa.dot.gov/retro
Manual on Uniform Traffic Control Devices (MUTCD) – http://mutcd.fhwa.dot.gov
ASTM – http://www.astm.org
AASHTO – http://www.transportation.org
Texas Transportation Institute – http://tti.tamu.edu/visibility