



Overhead Sign Sheeting and Illumination: A Survey of State Practice and Related Research

Requested by
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The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.

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Executive Summary

Background

Overhead signs on Caltrans freeways that require electrical power for illumination come with considerable utility expense to taxpayers. Upgrading existing or installing new overhead signs with Type XI sign sheeting, which can be seen by road users with headlight illumination alone, may provide a cost-effective alternative. Retroreflective sign sheeting requires no electrical power for sign illumination, saving electrical costs and demand. In addition, the nonelectrical sheeting is a countermeasure for copper wire theft (by removing the need for electrical sign components) and helps prevent graffiti (by removing the catwalks that supported the lighting infrastructure).

Since the December 1999 adoption of a program directive to use retroreflective sign sheeting for new overhead signs, Caltrans has been turning off sign illumination for some overhead signs as signs are upgraded with retroreflective sheeting. Caltrans is investigating the impact of possible statewide implementation of high-intensity Type XI reflective sign sheeting and wants to better understand the state of the practice for using some form of reflective sheeting among state departments of transportation (DOTs).

In support of Caltrans' inquiry, this Preliminary Investigation aims to assess the current state of the practice with regard to use of retroreflective sign sheeting and illumination on overhead signs through an examination of recent Caltrans survey results and a new survey effort directed to state DOT respondents. Supplementing the state-of-the-practice review is an investigation of related research.

Summary of Findings

Overhead Sign Lighting Guidance

We reviewed national guidance from an ongoing NCHRP project along with published NCHRP and Caltrans reports. The NCHRP project will develop guidelines for providing effective nighttime performance of overhead guide signs in site-specific situations. The findings of published reports include best practices from other agencies for meeting retroreflectivity requirements, Caltrans' current sign sheeting specifications and overhead sign lighting policies, and authorized vendors for Type XI sign sheeting. A 2013 draft report prepared by Caltrans District 11, *Overhead Type XI Sheeting & Fixed Lighting Systems*, describes a recent pilot using Type XI sign sheeting and fixed lighting for overhead signs. Included in the report are results from a survey of state DOT overhead sign sheeting and lighting practices.

Survey of Current Practice

To begin our analysis of overhead sign sheeting and lighting practices, we examined the results of the 2013 Caltrans survey of 48 state DOTs conducted by Caltrans District 11. Then we conducted a new survey to supplement these results, creating a customized series of questions for each respondent to the 2013 Caltrans survey. Representatives from 31 state DOTs responded to the new survey. Key findings from both surveys follow.

Sign Sheeting

Many states permit the use of more than one type of sheeting or use different sheeting types for a sign's background and legend. Type IV sheeting is the most commonly used background

sheeting type among survey respondents; for sign legends, Type XI sheeting is most often used by respondents, followed closely by Type IX sheeting. Ten states use Type XI sheeting exclusively for both background and legend of overhead signs.

Sign Lighting and Related Installations

Among states that continue to light overhead signs, LED is the most commonly used lighting, followed by metal halide lamps. Of the 14 states reporting removal of sign lighting from existing overhead sign structures, nine also remove lighting and electrical circuits. Four states remove catwalks from sign structures when removing sign lighting while five states opt to leave catwalks in place. Illinois, for example, keeps catwalks to facilitate sign panel maintenance or replacement. Massachusetts may choose to remove catwalks from existing structures to discourage sign vandalism such as tagging.

Use of Type XI Sheeting

We found that experience with using Type XI sheeting varied among state agencies. While many states are still evaluating the effectiveness of Type XI, others are using it exclusively and still others express reservations about its use:

- Delaware specifies Type XI exclusively because of its multifunctionality and longer service warranties over lesser grade sign sheeting.
- Nebraska found that the cost increase associated with Type XI sheeting is offset by eliminating sign lighting hardware costs.
- Louisiana reports no discernible difference to the driver in a test installation of Type XI sheeting alongside Type X on an overhead urban truss.
- Nevada found Type XI sheeting used for both the background and legend created a halo effect or washed out the legend.

Cost Savings or Other Benefits of Not Lighting Overhead Signs

States opting to eliminate lighting on some or all overhead signs cited savings in energy costs as well as costs associated with reduced maintenance and traffic control activities:

- Illinois estimates an annual savings of approximately \$5,000 for the average sign structure, which includes energy, relamping and repair.
- Washington State estimates an annual savings of approximately \$100,000 in electrical costs after eliminating lighting for overhead signs.
- Massachusetts notes that eliminating the need for traffic control that had been required when maintaining and repairing lighting results in fewer delays for drivers.
- Nevada reports a savings in maintenance costs associated with graffiti cleanup. Without lighting, the agency reports less vandalism on the signs or structures.

Adverse Effects or Concerns Associated with Unlit Overhead Signs

While a few states are still evaluating the impact of unlit overhead signs or Type XI sheeting, 20 states report no adverse effects. A few respondents reported a limited number of citizen comments or weather-related concerns associated with the lack of overhead sign lighting. Respondents from New Mexico and South Dakota, who had received complaints about the legibility or reflectivity of overhead signs, reported no complaints were received after implementing Type XI sheeting.

Related Research

We located several research reports and other publications from studies conducted within the last 10 years that address overhead sign sheeting and lighting practices. Among them, a 2014 conference proceeding describes a field experiment to compare three types of sign sheeting—Engineering Grade, Diamond Grade and High Intensity—to determine the sign sheeting material

that best improves sign visibility. A March 2012 Illinois DOT report contains the proceedings of a 2009 sign sheeting research demonstration held in Texas that led to the development of the new AASHTO Standard Specification for Retroreflective Sheeting for Traffic Control. Other publications address the impacts state DOTs have reported in connection with revisions to sign lighting policies.

We also provide findings from two in-progress research projects conducted on behalf of state DOTs:

- A review of Kansas DOT's sign lighting policy will examine the cost and safety benefits of using different retroreflective sheeting versus external lighting for overhead guide signs.
- A project sponsored by New York State DOT will generate specification and measurement procedures to ensure that retroreflective signs meet visual performance criteria when installed and after periods of use in the field.

Gaps in Findings

Projects in progress will add to the body of knowledge on this topic. Guidelines under development in an ongoing NCHRP project, concluding at the end of this year, will likely make a significant contribution to understanding effective nighttime performance of overhead guide signs. Other projects in progress, including those sponsored by Kansas and New York State DOTs, are expected to identify the cost and safety benefits of using retroreflective sheeting in lieu of external lighting and provide specification and measurement procedures.

The information compiled for this Preliminary Investigation is not reflective of an in-depth, 50-state survey of overhead sign lighting practices. While the 31 responses to the follow-up survey conducted for this project provided valuable information, there are gaps in the information available from these states and the 18 states not responding to the current survey.

Next Steps

Caltrans might consider the following as part of a continuing evaluation of the use of high-intensity Type XI reflective sign sheeting and lighting for overhead signs:

- Contacting one or more of the states that are using Type XI sign sheeting for both legend and background (Delaware, Florida, Hawaii, Illinois, Minnesota, Nebraska, New Mexico, South Dakota, Texas and Wisconsin) to learn more about their experience over time using this sheeting type:
- Contacting states contemplating a change in overhead sign policy or specifications (Idaho, Massachusetts, New York, North Dakota, Rhode Island, Utah, Washington and West Virginia) to gain a better understanding of the change process.
- Contacting states that have made relatively recent changes to overhead sign policy (Hawaii, Indiana and Maryland) to learn more about the impacts of those changes.
- Following up with states identifying specific cost savings associated with eliminating lighting from overhead signs (Illinois and Washington) to learn more about how those savings are estimated.
- Contacting researchers working on the Kansas and New York State DOT projects in progress to request interim results.

Detailed Findings

Overhead Sign Lighting Guidance

Below we provide national guidance from an ongoing NCHRP project and a recently published NCHRP synthesis. Caltrans guidance takes the form of a 1999 program directive now in effect. Finally, a 2013 draft report prepared by Caltrans District 11 describes a recent pilot using Type XI sign sheeting and provides background on local and national sign sheeting and lighting practices.

National Guidance

Guidelines for Nighttime Visibility of Overhead Guide Signs, NCHRP Project 05-20, expected completion date: December 31, 2014.

<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2954>

This project will develop guidelines for providing effective nighttime performance of overhead guide signs in site-specific situations. The project's web site indicates that the guidelines will "provide an objective measure of visual performance such as luminance that is independent of proprietary materials or specifications and be supported by analysis of any available human factors information, crash data, and life cycle costs." Publication of the project's final report is expected by the end of this year.

Related Resource:

Guidelines for Nighttime Visibility of Overhead Guide Signs: Phase I Interim Report, Paul Carlson, NCHRP Project 05-20, October 2011.

See Appendix A, provided to Caltrans.

From the abstract: This interim report documents and presents the results of the first phase of a study aimed at developing guidelines to determine when sign lighting is needed and if so, how much is needed. To date, a comprehensive literature review has been conducted and reported, focused telephone surveys have been completed with state traffic and lighting engineers, and proof-of-concept testing regarding the assessment of visual complexity has been completed.

A discussion of recent surveys conducted by state DOTs regarding sign lighting practices begins on page 23 of the report (page 34 of the PDF), including surveys conducted by:

- AASHTO Joint Technical Committee Survey (2010).
- Indiana (2009).
- Kansas (2011).
- Ohio (2003).
- Wisconsin (2008).

An extensive list of references begins on page 100 of the report (page 111 of the PDF).

NCHRP Synthesis 431: Practices to Manage Traffic Sign Retroreflectivity, Jonathan M. Re, Paul J. Carlson, 2012.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_431.pdf

From the introduction: The objective of this synthesis study was to provide examples of effective and advantageous practices that illustrate how different types of agencies can meet the retroreflectivity requirements. The aim of this study was to document the state of the practice and identify content that will assist other agencies that are exploring different methods for maintaining sign retroreflectivity. Information for this synthesis study was gathered from three distinct sources: published research, existing guidance and policy, and telephone surveys.

Caltrans Guidance

Overhead Guide Sign Illumination Policy, Traffic Operations Program Directive 99-02, California Department of Transportation, effective date: December 1, 1999.

<http://www.dot.ca.gov/hq/traffops/engineering/signdel/policy/99-02.pdf>

The policy indicates that new overhead sign installations “shall have retroreflective backgrounds, legends and borders.” With regard to lighting, “(f)ixed-lighting should be used to illuminate signs unless retroreflective luminance from headlights provides effective nighttime legibility.”

Authorized Materials List; Signing and Delineation Materials, 8-1, Prequalified and Tested Signing and Delineation Materials, California Department of Transportation, undated.

http://www.dot.ca.gov/hq/esc/approved_products_list/pdf/signing_and_delineation_materials.pdf

This list provides vendors approved by Caltrans to provide Type XI retroreflective sign sheeting.

Overhead Type XI Sheeting & Fixed Lighting Systems, Camille Aboufadel, Caltrans District 11, August 15, 2013.

See Appendix B, provided to Caltrans.

After testing Type XI sheeting without illumination in a pilot project on I-805/State Route 905, Caltrans District 11 now uses Type XI sheeting exclusively (for both background and legend) on new overhead signs, with the goal of allowing broader use of Type XI high-intensity reflective sheeting in lieu of fixed lighting. In support of this goal, this draft report includes a discussion of Caltrans signing practices; a comparison of Type IV and Type XI sheeting; and an examination of MUTCD overhead sign policy, national studies, and safety and benefit-cost analyses of traffic sign upgrades. The report also includes results from a survey of state DOT overhead sign sheeting and lighting practices.

Related Resource:

“Caltrans Tests Reflective Sheeting for Guide-Sign Visibility and Cost Savings,”

Marcia Lozier, *Roads and Bridges*, undated.

<http://www.roadsbridges.com/caltrans-tests-reflective-sheeting-guide-sign-visibility-and-cost-savings>

This article highlights the Caltrans District 11 pilot project on I-805/State Route 905 to “find a reflective sheeting that would meet the visual requirements of California drivers and eliminate future needs for electrical-sign lighting.” Electricity and maintenance cost savings are expected along with increased worker safety, better sign life-cycle costs and reductions in greenhouse gases.

Survey of Current Practice

Survey Approach

We began our examination of state practices on the use of sign sheeting and lighting for overhead signs with survey results appearing in an August 2013 draft report prepared by Caltrans District 11. (See the citation for **Overhead Type XI Sheeting & Fixed Lighting Systems** on page 7.) The August 2013 draft report includes results from a nationwide survey of state DOTs that posed the following questions:

- Do you light your overhead signs?
- Do you have any guidance or policy in place?
- What type sheeting are you currently using on your overhead signs?
- Do you know of any studies on that subject?

Survey responses from 44 states are reflected in the draft report. The draft report's author provided subsequent responses from four additional states shortly before publication of this Preliminary Investigation.

We conducted a new survey to supplement results from the 2013 Caltrans survey. Respondents from state DOTs were asked a customized series of questions based on their responses to the 2013 Caltrans survey that addressed the following topics, as applicable:

- For states illuminating some or all overhead signs:
 - The types or locations of signs that continue to be illuminated.
 - The type of illumination used for these signs.
- When removing sign lighting from existing signs, if lighting, electrical circuits (including the copper wires leading to the signs) and catwalks are also removed.
- The use of Type XI sheeting, including reasons for specifying it, evaluating its use and reasons why Type XI sheeting is not used as an agency standard.
- Cost savings and other benefits associated with eliminating illumination.
- Any adverse effects or concerns related to not lighting overhead signs.

We received responses to the new survey from 31 state DOTs:

- Arizona.
- Arkansas.
- Delaware.
- Florida.
- Idaho.
- Illinois.
- Iowa.
- Kentucky.
- Louisiana.
- Maryland.
- Massachusetts.
- Michigan.
- Minnesota.
- Mississippi.
- Missouri.
- Montana.
- Nevada.
- New Jersey.
- New Mexico.
- New York.
- North Dakota.
- Oregon.
- Pennsylvania.
- Rhode Island.
- South Carolina.
- Tennessee.
- Texas.
- Vermont.
- Virginia.
- Washington.
- Wyoming.

See Appendix C2: 2014 Survey Results by State, provided to Caltrans, for the full text of all responses to the new survey conducted for this Preliminary Investigation.

Survey Results

Below is a summary of key findings from the composite survey results (2013 Caltrans survey and the new survey), organized into eight topic areas related to the use of sign sheeting and lighting for overhead signs:

- 1) Extent of overhead sign lighting.
- 2) Use of sign sheeting.
- 3) Lighting used for overhead signs.
- 4) Removing sign lighting and related installations.
- 5) Experience with Type XI sheeting.
- 6) Cost savings or other benefits of not lighting overhead signs.
- 7) Adverse effects or concerns associated with unlit overhead signs.
- 8) Formal policies or guidance.

See Appendix C1: Composite Survey Results by State, provided to Caltrans, to review these combined survey results by state.

1) Extent of Overhead Sign Lighting

Forty-eight survey respondents reported the extent of sign lighting used for overhead signs. The table below categorizes survey responses using the following levels of overhead sign lighting:

- None (17 states; 35 percent of respondents).
- Very few (7 states; 15 percent of respondents).
- No new signs (six states; 13 percent of respondents).
- Case by case (15 states; 31 percent of respondents).
- All (three states; 6 percent of respondents).

The three states continuing to light overhead signs as a general practice are evaluating the use of Type XI sheeting or considering modifications to sign lighting policies.

Categorizing the Extent of Overhead Sign Lighting		
Extent of Overhead Sign Lighting	State	Details
None	Arkansas	Stopped lighting signs many years ago.
	Connecticut	Stopped lighting signs in the mid-1980s.
	Delaware	Stopped lighting signs 10 years ago.
	Georgia	Stopping lighting signs years ago.
	Indiana	New policy in 2009.
	Kentucky	Stopped lighting signs two decades ago.

Categorizing the Extent of Overhead Sign Lighting

Extent of Overhead Sign Lighting	State	Details
	Louisiana	No lighting since 1986.
	Maine	Not available.
	Michigan	Eliminated lighting 25 years ago.
	Mississippi	Not available.
	Missouri	Eliminated lighting in mid-1990s.
	Montana	Not available.
	New Hampshire	No lighting for 20 years or more.
	New Mexico	Not available.
	South Dakota	Not available.
	Tennessee	Not available.
	Vermont	Not available.
Very few	Illinois	Policy permits very rare exceptions where engineering judgment indicates that appropriate visibility will not be obtained.
	Massachusetts	Eliminated illumination in early 1980s; lights signs in tunnel system.
	Minnesota	In general, MnDOT does not light its signs.
	Oregon	Sign lighting will only be considered when adverse vertical or horizontal alignment requires its use (<5% of signs).
	Rhode Island	Default is to not light signs.
	Texas	Since 1993, no lighting has been required for signs with Type C sheeting.
	Wisconsin	Lighting few signs in the Milwaukee metro area.
No new signs	Hawaii	Currently transitioning to not lighting overhead signs.
	Iowa	Have not actively been removing or turning off the existing lights; as new signs are installed, lighting is removed.
	Kansas	Eliminating lighting on overhead signs; currently functioning lights will remain lit; as signs become inoperable the agency is not replacing them.
	Nebraska	No longer lighting overhead signs replaced with Type XI sheeting.

Categorizing the Extent of Overhead Sign Lighting

Extent of Overhead Sign Lighting	State	Details
No new signs	North Carolina	Signs are lighted if the agency believes there is a need based on alignment; when overhead signs are replaced, lights are turned off.
	Ohio	Lighting removed when sheeting is upgraded; otherwise, lighting remains on existing signs.
Case by case	Alabama	Lights overhead signs on a case-by-case basis.
	Alaska	Determination to illuminate signs is made in the design process taking into consideration site conditions.
	Arizona	Only when Type IX, Type XI or Type D sheeting is not used.
	Florida	For geometric conditions where headlights do not provide sufficient illumination.
	Maryland	All overhead signs with sheeting less than Type XI are lit; sign lighting criteria are specified in July 2013 policy.
	Nevada	Currently, 40% of overhead signs are lit; this percentage is expected to go down.
	New Jersey	Need for external lighting is based on 1,200-foot minimum sight lines, fog areas, complex interchanges and continuity of a corridor with existing signs already lit.
	New York	Overhead sign lighting typically exists in more urban areas.
	Pennsylvania	64.7% of sign structures are lit.
	South Carolina	Most sign structures having lights are on Interstate mainline.
	Utah	Revising policy to allow use of Type XI sheeting in place of maintaining or installing overhead sign lighting.
	Virginia	Signs with Type IX or XI do not require lighting except at major decision points (Interstate to Interstate) or other local (background) lighting issues.
	Washington	Lighting provided for signs with Exit Only panels in noncontinuous illumination areas and guide signs for left side exits in all areas are illuminated.
West Virginia	Evaluating use of differing types of sign sheeting and sign lighting with regard to topography, urbanized areas and ambient lighting concerns.	

Categorizing the Extent of Overhead Sign Lighting		
Extent of Overhead Sign Lighting	State	Details
	Wyoming	Lighting needed if the sign is in a headlight-disadvantaged location or in an urban area with lots of visual clutter.
All	Colorado	Recently installed Type XI sheeting on several corridors on an experimental basis.
	Idaho	Currently evaluating the use of Type XI sheeting without sign lighting.
	North Dakota	Considering modifications to its sign lighting policy.

2) Use of Sign Sheeting

We asked respondents to indicate the type of sign sheeting used for overhead signs. In many cases, a state permits the use of more than one type of sheeting or uses different sheeting types for a sign’s background and legend.

Type IV sheeting is the most commonly used background sheeting type among survey respondents; for sign legends, Type XI sheeting is most often used by respondents, followed closely by Type IX sheeting.

Ten states use Type XI sheeting exclusively for both background and legend of overhead signs.

- Delaware.
- Florida.
- Hawaii.
- Illinois.
- Minnesota.
- Nebraska.
- New Mexico.
- South Dakota.
- Texas.
- Wisconsin.

The tables below summarize survey responses with regard to the use of sign sheeting, breaking out responses by background and legend sheeting type.

Background Sheeting Usage		
Background Sheeting Type	Number of States	States
AASHTO M268-09 Type D	1	Arizona
Grade C (regular grade)	1	North Carolina
Type II	1	Washington
Type III	11	Arkansas, Kentucky, Maine, Mississippi, New York (or better), North Dakota, Ohio, Pennsylvania, Rhode Island, Tennessee (or better), Washington

Background Sheeting Usage		
Background Sheeting Type	Number of States	States
Type IV	18	Alabama, Connecticut, Idaho, Indiana (or better), Iowa, Kansas (or better), Kentucky, Maine, Michigan, Missouri, Montana (or better), Nevada, New Hampshire, Ohio, Pennsylvania, Washington, West Virginia, Wyoming
Type VIII	5	Massachusetts (or better), Ohio, Rhode Island, South Carolina, Washington
Type IX	13	Alaska, Arizona, Colorado, Georgia, New Jersey (mostly), Ohio, Oregon, Rhode Island, South Carolina, Utah (or better), Vermont, Virginia, Washington
Type X	1	Louisiana
Type XI	15	Arizona, Delaware, Hawaii, Florida, Illinois, Maryland, Minnesota, Nebraska, New Mexico, Ohio, South Dakota (or better), Texas, Vermont, Virginia, Wisconsin

Legend Sheeting Usage		
Legend Sheeting Type	Number of States	States
AASHTO M268-09 Type D	1	Arizona
Grade A (premium grade)	1	North Carolina
Type III	6	Georgia, New York (or better), North Dakota, Rhode Island, Tennessee, Washington
Type IV	7	Alabama (or Diamond Grade), Connecticut, Indiana (or better), Iowa, Kansas (or better), New Hampshire, Washington
Type VIII	8	Kentucky, Massachusetts (or better), New Hampshire, Ohio, Pennsylvania, Rhode Island, South Carolina, Washington
Type IX	21	Arizona, Alaska, Arkansas, Colorado, Idaho, Kentucky, Missouri, Montana (or better), Nevada, New Hampshire, New Jersey (mostly), Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Utah (or better), Vermont, Virginia, Washington, Wyoming
Type X	1	Louisiana

Legend Sheeting Usage		
Legend Sheeting Type	Number of States	States
Type XI	23	Arizona, Delaware, Florida, Hawaii, Illinois, Kentucky, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Mexico, Ohio, Pennsylvania, South Dakota (or better), Texas, Vermont, Virginia, West Virginia (now converting), Wisconsin

3) Lighting Used for Overhead Signs

Some of those states continuing to light at least some overhead signs provided information about the type of lighting used. The table below summarizes survey responses.

Lighting Used for Overhead Signs		
Type of Fixture	State	Details
Fluorescent	Arizona	85-watt induction fluorescent fixture.
High-pressure sodium	Illinois	Also uses fluorescent fixtures.
	Nevada	150-watt high-pressure sodium.
	Virginia	150-watt high-pressure sodium.
Induction	Washington	Used for new projects.
LED	Idaho	Used for all new sign structures when lighting is required.
	Maryland	LED luminaires.
	New Jersey	LED on the LumiTrac system.
	North Dakota	Transitioning from metal halide.
	Oregon	Project under design.
	South Carolina	Plans to upgrade sign lights to LED to reduce power consumption; first project should be completed later this year.
	South Dakota	Not available.
	West Virginia	Transitioning from mercury vapor and metal halide.
	Wyoming	Converting all sign lighting to LED.
Mercury vapor	Washington	Existing systems.
	West Virginia	Existing systems.
Metal halide	Minnesota	150- or 250-watt metal halide lamps.

Lighting Used for Overhead Signs		
Type of Fixture	State	Details
	New Jersey	250-watt metal halide.
	New York	Not available.
	North Dakota	LED used for last couple installations.
	Oregon	Current practice for lighting signs.
	Pennsylvania	100-watt coated ceramic metal halide lamps.
	West Virginia	Existing systems.

4) Removing Sign Lighting and Related Installations

We asked those states indicating a relatively recent decision to eliminate lighting for overhead signs if they also removed sign lighting and related installations when deactivating sign lighting. The table below summarizes survey responses.

States Removing Sign Lighting and Related Installations		
Action	State	Comments
Remove sign lighting	Arizona, Connecticut, Delaware, Illinois, Indiana, Iowa, Massachusetts, Minnesota, Nevada, North Carolina, Ohio, Washington, Wisconsin, Wyoming	<p><i>Connecticut.</i> Removed when signs were replaced using reflectorized materials.</p> <p><i>Delaware.</i> Removed about 10 years ago without much fanfare or thorough study.</p> <p><i>Iowa.</i> Removed as new signs installed.</p> <p><i>North Carolina.</i> May remove lighting fixtures when signs are replaced.</p>
Remove lighting and electrical circuits	Arizona, Delaware, Illinois, Iowa, Massachusetts, Minnesota, Nevada, Ohio, Washington	<p><i>Iowa.</i> Remove to the footing of the structure.</p> <p><i>Massachusetts.</i> Power connection is also capped. For structural stability reasons, conduits are normally retained until the sign support structure is replaced.</p> <p><i>Nevada.</i> Lighting and wiring to the service are removed, but the infrastructure is left in place.</p> <p><i>Ohio.</i> Removal includes, as a minimum, the physical removal of the luminaires and luminaire support assemblies.</p>
Remove catwalks	Arizona, Iowa, Minnesota, Nevada	Not available.

Some states opt not to remove catwalks when removing sign lighting. These include:

- Delaware.
- Illinois (walkways left in place to facilitate sign panel maintenance or replacement).
- Massachusetts (catwalks normally retained until the sign support structure is replaced; some cases where existing catwalks have been removed to discourage sign vandalism such as tagging).
- New Jersey.
- Washington (catwalk removal not applicable for most locations).

5) Experience with Type XI Sheeting

Some states using Type XI sign sheeting provided background on the decision to begin using this type of sign sheeting. Other respondents not using Type XI sheeting as an agency standard indicated whether they had considered its use or if Type XI sign sheeting was being used in experimental applications. Other states not using Type XI sign sheeting provided the rationale for not using this sheeting type.

Reasons for Specifying Type XI Sheeting

Some states provided perspective on why they are currently specifying Type XI sign sheeting for overhead signs.

- *Delaware*. Prior to approval of Type XI sheeting, Delaware DOT specified Type IX for all overhead sign panels. Currently, the agency specifies Type XI exclusively as it considers it to be multifunctional and provides longer service warranties over lesser grade sign sheeting.
- *Nebraska*. The agency has found that the increase in cost for Type XI sheeting is recovered by the elimination of sign lighting hardware costs.
- *South Carolina*. Beginning with its next project, South Carolina DOT will use Type XI as the standard for applications where lighting is used. Existing lighting systems will be maintained after the new signs are installed.
- *Utah*. Utah DOT is revising its policy on highway lighting to allow the use of Type XI sheeting in place of maintaining or installing overhead sign lighting.
- *Virginia*. Type IX is the standard that appears on Virginia DOT's preapproved materials list. Manufacturers have submitted Type XI sheeting, and if it is approved as an equivalent to Type IX, its use is a sign fabrication decision.

Evaluating the Use of Type XI Sheeting

Other states are evaluating the use of Type XI sign sheeting as a standard for overhead signs.

- *Idaho*. Idaho DOT has installed a few signs with Type XI sheeting and without sign lighting at select test locations. If the test is successful, the current policy on sign lighting will be reviewed.

- *Kansas*. Type XI sheeting has been implemented in select locations for observation, though no formal studies are being conducted at these locations to determine their performance.
- *Massachusetts*. Recently, Massachusetts DOT began using Type XI purple sheeting on new overhead E-ZPass toll signing along the state's turnpike system. While the initial results with the E-ZPass signs appear promising, the agency will conduct additional tests with the Type XI sheeting in other signing situations and field locations before making a final decision regarding the possible use of Type XI sheeting as a statewide standard.
- *New Jersey*. New Jersey DOT has some limited test cases using Type XI, Type IX and Type X sheeting with Clearview font and is considering expanding the use of Type XI sheeting.
- *New York*. New York State DOT is investigating the use of Type XI sheeting in lieu of lighting and finalizing a performance-based specification for reflective sheeting.
- *Oregon*. Oregon DOT has begun an examination of the use of Type XI sign sheeting and is considering installing some test signs.
- *Rhode Island*. Rhode Island DOT has considered the use of Type XI sheeting for overhead and other types of signs. The agency is updating its Standard Specifications for sign sheeting; it is not known if the specifications will require the use of Type XI sign sheeting.
- *Washington*. Washington State DOT has used Type XI sheeting sparingly to date. The agency is considering using Type XI sheeting for the legend and Type IV sheeting for the background of overhead signs.

Why Type XI Sheeting is Not the Agency Standard

Some respondents expressed reservations about its use or explained why Type XI sheeting is not the agency standard.

- *Georgia*. The respondent noted that some consider Type XI sheeting to be distractingly bright. The respondent posits that some of the complaints about brightness may be a result of the use of a different sheeting type for copy than for the sign's background.
- *Iowa*. Seven to 10 years ago, Iowa DOT installed some signs with Type XI sheeting for comparison to Type IV sheeting. The agency changed one of three overhead signs to Type XI sheeting and installed it next to two other signs with lower grades of sheeting. Visual observation indicated no significant difference in legibility to justify the additional cost for the Type XI sheeting.
- *Kentucky*. The agency allows the use of either Type IX or Type XI sheeting from its approved products list, with sign contractors typically electing to use materials from the Type IX list. The agency has not considered mandating the use of Type XI sheeting.
- *Louisiana*. No discernible difference to the driver was found in a test installation of Type XI sheeting side by side with Type X on an overhead urban truss. Given test results, the agency lacked the justification to use the brighter Type XI sheeting.
- *Nevada*. Nevada DOT has found that its standard of Type IV sheeting for the background and Type IX or Type XI for the legend of overhead signs provides a good contrast for the sign message. Nevada DOT notes its own experience and study results that have found Type XI sign sheeting used for both the background and legend created a halo effect or washed out the legend.

6) Cost Savings or Other Benefits of Not Lighting Overhead Signs

Three states opting to eliminate lighting on some or all overhead signs cited specific dollar savings.

- *Illinois.* While the agency has not conducted a comprehensive study on actual cost savings, about four years ago, Illinois DOT estimated the annual cost savings when eliminating lighting for the average sign structure, including energy, relamping and repair, at approximately \$5,000.
- *Minnesota.* A 1995 sign lighting study indicated that the initial cost of fabricating and installing the lighting system, catwalk, sign structure, guardrail and footing for a typical sign was \$32,500 per structure (\$5,500 for the lights and catwalk alone).
- *Washington.* Electrical costs are reduced by about \$100,000 per year by eliminating lighting for overhead signs.

In addition to a reduction in energy costs, four states—Arizona, Delaware, Massachusetts and Washington—reported cost savings associated with maintenance and traffic control activities.

- Massachusetts DOT also noted that eliminating the need for traffic control that had been required when maintaining and repairing lighting results in fewer delays for drivers.
- For Nevada DOT, cost savings include maintenance costs for graffiti cleanup. Without lighting, the agency reports less vandalism on the signs or structures, which are no longer as accessible to vandals.

7) Adverse Effects or Concerns Associated with Unlit Overhead Signs

We asked respondents to report any adverse effects or concerns associated with not lighting overhead signs. The table below summarizes those responses reporting no adverse effects and indicates each state’s current overhead sign lighting status.

States Reporting No Adverse Effects of Not Lighting Overhead Signs			
State	Overhead Sign Lighting Status	State	Overhead Sign Lighting Status
Arizona	<i>Case by case.</i> Only when Type IX or XI or Type D sheeting is not used.	Mississippi	<i>None.</i>
Arkansas	<i>None.</i> Stopped lighting signs many years ago.	Missouri	<i>None.</i> Eliminated lighting in mid-1990s.
Delaware	<i>None.</i> Stopped lighting signs 10 years ago.	Montana	<i>None.</i>

States Reporting No Adverse Effects of Not Lighting Overhead Signs			
State	Overhead Sign Lighting Status	State	Overhead Sign Lighting Status
Illinois	<i>Very few.</i> Policy permits very rare exceptions where engineering judgment indicates that appropriate visibility will not be obtained.	Nevada	<i>Case by case.</i> Currently, 40% of overhead signs are lit; this percentage is expected to go down.
Iowa	<i>No new signs.</i> Not actively removing or turning off the existing lights; as new signs are installed, lighting is removed.	Oregon	<i>Very few.</i> Sign lighting will only be considered when adverse vertical or horizontal alignment requires its use (<5% of signs).
Kentucky	<i>None.</i> Stopped lighting signs two decades ago.	Rhode Island	<i>Very few.</i> Default is to not light signs.
Maryland	<i>Case by case.</i> Signs with sheeting less than Type XI are lit; new policy in July 2013.	Tennessee	<i>None.</i>
Massachusetts	<i>Very few.</i> Eliminated illumination in early 1980s.	Vermont	<i>None.</i>
Michigan	<i>None.</i> Eliminated lighting 25 years ago.	Virginia	<i>Case by case.</i> Signs with Type IX or Type XI do not require lighting except at major decision points or other local lighting issues.
Minnesota	<i>Very few.</i> In general, MnDOT does not light its signs.	Wyoming	<i>Case by case.</i> Lighting needed if the sign is in a headlight-disadvantaged location or in an urban area with lots of visual clutter.

A few respondents reported comments from citizens or weather-related concerns associated with the lack of overhead sign lighting.

- Citizen comments:
 - *North Carolina.* While North Carolina DOT has not seen an increase in night crashes, the agency has received a few comments from citizens.

- *Pennsylvania*. Since 2005, when requirements for overhead lighting were reduced, Pennsylvania DOT has received three to four complaints about the lack of overhead sign lighting or that existing overhead sign lighting has been turned off.
- Weather-related concerns:
 - *Florida*. The only complaint the survey respondent has received has been related to early morning dew and rain that restrict the retroreflectivity of the sheeting.
 - *South Carolina*. Areas of the state sometime experience heavy dew in the spring and fall as well as frost in the winter months. These conditions can make unlighted signs very difficult to read.

Two respondents who had received complaints about the legibility or reflectivity of overhead signs reported no complaints were received after moving to the use Type XI sheeting.

- *New Mexico*. While the respondent indicated that the sign reflectivity of previously used sheeting types did not work well with high-profile trucks, since moving to Type XI sheeting, the survey respondent is not aware of any complaints.
- *South Dakota*. At one time complaints were received from truck drivers with respect to legibility and reflectivity of overhead signs. Since using Type XI sheeting on the sign legend, no complaints have been received.

A few states are still evaluating the impact of not lighting overhead signs or the use of Type XI sheeting.

- *Maryland*. The full impact of a new lighting policy implemented in July 2013 has yet to be determined.
- *New Jersey*. New Jersey DOT does not have enough of a sampling of Type XI sheeting applications to draw conclusions.
- *Washington*. Washington State DOT will be evaluating the impacts of heavy frost and readability of overhead signs at night.

8) Formal Policies or Guidance

We asked respondents with formal policies or guidance related to sign lighting or retroreflective materials to provide links or access to relevant documentation. These documents are presented in the table below.

State DOT Sign Lighting and/or Reflectivity Policies or Guidance	
State	State Policy or Guidance
Arizona	Section 790 – Overhead Guide Sign Lighting, Section 700, Illumination, ADOT Traffic Engineering Policies, Guidelines, and Procedures, Arizona Department of Transportation, May 2010, available at http://www.azdot.gov/docs/businesslibraries/790.pdf?sfvrsn=0 .
Delaware	See page 20 of Lighting Design Guidelines, Delaware Department of Transportation, revised October 2012, available at http://www.deldot.gov/information/pubs_forms/manuals/lighting/lighting_guidelines_2012-10-01.pdf .
Florida	Section 7.2.5 of Plans Preparation Manual, Florida Department of Transportation, 2014, available at http://www.dot.state.fl.us/rddesign/PPMManual/2014/Volume1/Chap07.pdf . External Sign Lighting on Overhead Signs, Roadway Design Bulletin 13-12, Florida Department of Transportation, October 11, 2013, available at http://www.dot.state.fl.us/rddesign/Bulletin/RDB13-12.pdf .
Idaho	See page 7 of Idaho DOT’s Sign Design Manual, available at http://itd.idaho.gov/manuals/ManualProduction/SignChart/ITDSignDesignManual.pdf .
Illinois	See page 1007 of the Illinois DOT’s Standard Specifications, available at http://www.dot.il.gov/desenv/spec2012/Div1000.pdf
Indiana	Deactivation of Overhead Sign Lighting and Overhead Sign Sheeting Requirements for New Installations, Operations Memorandum 09-06, Indiana Department of Transportation, November 24, 2009; see Appendix D, provided to Caltrans.
Kentucky	Sign sheeting is addressed in the agency’s approved products list, available at http://transportation.ky.gov/Materials/Documents/LAM.PDF .
Maine	Qualified Products List of Sign Sheeting Material, Maine Department of Transportation, March 2014, available at http://www.maine.gov/mdot/tr/documents/pdf/sheeting.pdf .
Massachusetts	2012 Supplemental Specifications (Subsection 828.41 and Materials Specification M9.30.0), available at http://www.massdot.state.ma.us/Portals/8/docs/construction/SupplementalSpecs20120615.pdf .

State DOT Sign Lighting and/or Reflectivity Policies or Guidance

State	State Policy or Guidance
Michigan	<p>Traffic Sign Design, Placement, and Application Guidelines, Michigan Department of Transportation, May 2014, available at http://mdotcf.state.mi.us/public/tands/Details_Web/mdot_signing_design_placement_application_guidelines.pdf.</p> <p>Appendix C, page C-10, of the MDOT Signing Design Placement Application Appendix; see Appendix E, provided to Caltrans.</p>
Minnesota	<p>See page 6-13 of MnDOT's Traffic Engineering Manual, available at http://www.dot.state.mn.us/trafficeng/publ/tem/2009/Chapter-06.pdf.</p>
Missouri	<p>Section 903.4, Overhead Guide Sign Mounting, Engineering Policy Guide, Missouri Department of Transportation, available at http://epg.modot.org/index.php?title=903.4_Overhead_Guide_Sign_Mounting.</p>
Montana	<p>Policy on Sign Sheeting Materials for Permanent Signs, Management Memo 10-02, Montana Department of Transportation, September 29, 2010; see Appendix F, provided to Caltrans.</p>
New Mexico	<p>Sign Sheeting Requirements, Intra Departmental Correspondence, New Mexico Department of Transportation, August 20, 2012; see Appendix G, provided to Caltrans.</p>
North Carolina	<p>S-68, Standard Practice for Retroreflective Sign Sheeting, Traffic Engineering Policies, Practices, and Legal Authority, North Carolina Department of Transportation, March 4, 2009, available at https://connect.ncdot.gov/resources/safety/TEppl/TEPPL%20All%20Documents%20Library/S-68pr1.pdf.</p>
Ohio	<p>Chapter 212, Sign Lighting, Traffic Engineering Manual, Ohio Department of Transportation, April 20, 2012, available at http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/TEM/Documents/Part_02_Complete_011813Revision_bookmarked_010913.pdf.</p>
Oregon	<p>Chapter 2: Signs and Policy by MUTCD Section, Sign Policy and Guidelines, Oregon Department of Transportation, March 2013, available at http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/english_chapter_2.pdf.</p> <p>See page 4 of Lighting Policy and Guidelines, Oregon Department of Transportation, January 2003, available at http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/lighting_policy_and_guidelines.pdf.</p>

State DOT Sign Lighting and/or Reflectivity Policies or Guidance

State	State Policy or Guidance
Pennsylvania	Publication 111, standard drawing TC-8701A, sheet 1 of 13 (see page 41 of the PDF, available at ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20111.pdf).
Texas	DMS – 8300, Sign Face Materials, Departmental Materials Specifications, Texas Department of Transportation, November 2013, available at ftp://ftp.dot.state.tx.us/pub/txdot-info/cst/DMS/8000_series/pdfs/8300.pdf .
Utah	Section 02890, Retroreflective Sheeting, 2012 Standard Specifications for Road and Bridge Construction, Utah Department of Transportation, January 1, 2012, available at https://www.udot.utah.gov/main/uconowner.gf?n=7595307898760091 .
Washington	See page 1020-5 of Chapter 1020, Signing, WSDOT Design Manual, Washington State Department of Transportation, July 2011, available at http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1020.pdf .
Wyoming	See page 4 of the WYDOT Signing Manual, Wyoming Department of Transportation, 2013, available at http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Traffic%20data/2013%20Signing%20Manual%20Final.pdf .

Related Research

State DOT Activities

Below we highlight published research and two in-progress research projects conducted on behalf of state DOTs. We also provide a sampling of the impacts state DOTs have reported in connection with revisions to sign lighting policies.

Published Research

Use of High Intensity Reflective Sheeting in Lieu of External Lighting of Overhead

Roadway Signs, N. Mike Jackson, Paul J. Carlson, Fan Ye, Georgia Jackson, Florida Department of Transportation, June 2013.

http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_MNT/FDOT-BDK82-977-07-rpt.pdf

This study sought to determine whether high-intensity reflective sheeting can be used to replace overhead sign lighting. The researchers' tasks included:

- Collecting field data to assess the conditions of Florida signs in terms of MUTCD minimum retroreflectivity levels.
- Developing a luminance computation model to calculate sign legend luminance under various situations, including different sign lighting technologies, different geometrics and sign locations, and different amounts of sign dirt and sign aging.
- Comparing the calculated luminance of a specific sign with the legibility luminance levels required by older drivers.

Researchers used a life-cycle cost spreadsheet to calculate the cost of replacing the current sign sheeting in Florida with high-reflective sheeting and the cost of installing and upgrading sign lighting. They found that in the conditions examined (on straight and flat roadways or horizontal curves, in rural areas or urban areas), the most cost-effective approach to maintain overhead guide luminance is to use (installing or replacing with) induction or LED luminaires.

The results also indicated that using either Type VIII or Type XI legend sheeting materials and forgoing sign lighting is a viable alternative to maintain luminance and contain costs.

Researchers recommended using sign lighting with Type XI sheeting materials:

- Along horizontal curves in rural areas with radii of 880 feet.
- Along horizontal curves in urban areas with radii of 2,500 feet or less.

Related Resource:

External Sign Lighting on Overhead Signs, Roadway Design Bulletin 13-12, Florida Department of Transportation, October 11, 2013.

<http://www.dot.state.fl.us/rddesign/Bulletin/RDB13-12.pdf>

Requirements of this new directive are consistent with researchers' recommendations in the June 2013 Florida DOT report cited above, including:

- New Overhead Signs – Overhead Signs will no longer require external lighting unless the sign is located along a horizontal curve with radii of 880 feet or less in rural areas and radii of 2500 feet or less in urban areas.

- For Existing Overhead Signs with External Sign Lighting – Continue to light the sign until the lighting fixture/system or sign panel requires replacement or major repairs. Then replace existing panel with new panel meeting the current MUTCD requirements and with Type XI sheeting and remove the existing lighting system (including fixtures, support brackets, conduit, hardware, etc.). However, if the sign is located along a horizontal curve with radii of 880 feet or less in rural areas and radii of 2500 feet or less in urban areas replace the mercury vapor fixtures with approved energy efficient alternatives such as induction or LED fixtures.
- Existing Overhead Signs Without Lighting – Replace existing panel when it no longer meets reflectivity requirements with new panel using Type XI sheeting.

Research and Recommendations for a Statewide Sign Retroreflectivity Maintenance Program, Paul J. Carlson, Laura Higgins, Jon Re, Texas Department of Transportation, April 2012.

<http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6408-1.pdf>

Researchers examined TxDOT's current sign retroreflectivity maintenance practices and made three recommendations to bring TxDOT's current practices into compliance with the 2011 Texas MUTCD:

- TxDOT should provide calibration signs to the maintenance sections.
- A standardized form should be used to conduct inspections and document inspections.
- A training program should be implemented to educate the inspectors on how to conduct the inspections and the importance of sign retroreflectivity.

Texas – AASHTO Retroreflective Sign Sheeting Specifications, Liang Y. Liu, Illinois Department of Transportation, March 2010.

<http://ict.illinois.edu/publications/report%20files/FHWA-ICT-10-065.pdf>

Illinois DOT was appointed to chair an AASHTO effort to develop a specification to simplify and improve how sign sheeting materials are specified for state DOTs. This report contains the proceedings of a 2009 sign sheeting research demonstration, "Standard Specification for Retroreflective Sheeting for Traffic Control," held in Texas. The report also summarizes the discussions leading to a final draft specification that was distributed to the AASHTO Subcommittee on Materials Tech Section 4d Sign Sheeting Task Force in July 2009. This effort led to a new AASHTO Standard Specification for Retroreflective Sheeting for Traffic Control (M 268-09).

Development of a Model Performance-Based Sign Sheeting Specification Based on the Evaluation of Nighttime Traffic Signs Using Legibility and Eye-Tracker Data, Paul Carlson, Jeff Miles, Eun Sug Park, Sarah Young, Susan Chrysler, Jeremy Clark, Texas Department of Transportation, September 2010.

<http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-5235-1-VOL1.pdf>

From the abstract: Using the results of the nighttime legibility and eye-tracker studies, the researchers developed a classification scheme for retroreflective sheeting materials based on luminance requirements derived from the study. Then the researchers modeled the retroreflective geometries resulting from common roadway scenarios (sign position, roadway type and cross-section, vehicle size, etc.). Using the luminance requirements derived from the study and market-weighted headlamp flux matrices, the researchers developed an approach to sign sheeting specification that is based on nighttime driver needs.

Field Evaluation of Unlighted Overhead Guide Signs, Indiana Department of Transportation, November 13, 2009.

See Appendix I, provided to Caltrans.

Researchers assessed the feasibility of eliminating the lighting of overhead guide signs when using microprismatic materials with higher retroreflectivity. *From page 7 of the report:*

Using prismatic Type IX, Type VIII, or Type IV legends on Type IV backgrounds on unlighted overhead guide signs should not result in any detrimental information acquisition or adverse safety effects for the majority of the driving public. The evaluator results are based upon a group of traffic engineers and technicians ranging in age from 30's to 60's riding in a minivan and dump truck.

The evaluators recommend that INDOT prepare a statewide implementation plan and schedule to discontinue the practice of providing and maintaining luminaries for overhead signs and replace step by step all overhead signs in the state with prismatic sheeting legends (Type IV, Type VIII or Type IX) on Type IV background sheeting.

The change of practice from lighted to unlighted overhead signs with white prismatic legends on green Type IV background will have a number of benefits including the elimination of the luminaries installation costs, the electricity requirements at overhead signs, the electricity costs, the maintenance and associated traffic control costs, and the wasted illumination towards the night sky.

Evaluation of New Reflective Materials for Overhead Highway Signage, John D. Bullough, Nicholas P. Skinner, Conan P. O'Rourke, New York State Department of Transportation, July 2008.

https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-05-08%20Reflective%20Materials_July%202008_0.pdf

From the abstract: Unlighted highway signs using newly developed retroreflective materials were installed along the Gowanus Expressway. Photometric measurements of the signs were used to assess the visibility of the signs using the relative visual performance model. The calculated visibility of the unlighted signs was similar to that of a lighted sign conforming to present recommendations for exterior sign lighting. The results of a series of subjective observations of sign contrast suggest that individuals can see differences in sign appearance that could have little or no impact on visual performance.

Driver Ratings of Overhead Guide Sign Legends, Chalmers Engineering Services Inc., Paul J. Carlson, Arizona Department of Transportation, 2005.

<ftp://ftp.dot.state.fl.us/lts/co/construction/RetroreflectivityPresentations/Final%20AZLoop202%20Legend%20Rpt.pdf>

From the Recommendations on page 25 of the PDF:

The results of this study consistently show that the proposed Type XI performs at a higher level, photometrically and preferentially, than any of the other available prismatic retroreflective sheeting materials. The results are consistent across all distances of interest, among older drivers, and among participants in heavy vehicles. No other material performed as well as the proposed Type XI across all of these variables. In addition, the proposed Type XI is at least as different as other ASTM Typed materials even though it does not have an official designation yet (for instance, the proposed Type XI is more different from Type IX than Type VII is different from Type VIII). Therefore, a recommendation based on this report should be made to the ASTM to revise their sheeting specification (D4956) to include a new type designation representative of 3M material tested herein.

In-Progress Research

A Review of KDOT Overhead Guide Sign Lighting Policy, Project KSU-11-6, University Transportation Center at Kansas State University, project in progress.

<https://transport.engg.ksu.edu/files/transport/imported/Reports/KSU-11-6.pdf>

From the research preproposal: The research objective of this project is to determine the minimum retroreflectivity levels for the overhead guide signs that will satisfy the FHWA requirements and be consistent with minimizing life cycle costs. It will include a study of the cost and safety benefits of using different retroreflective sheeting versus external lighting for the overhead guide signs, and the most cost-effective means of external illumination considering the life-cycle costs of newer, lower energy systems. Sponsor: Kansas Department of Transportation.

High Visibility Reflective Sign Sheeting Evaluation, Rensselaer Polytechnic Institute, expected completion date: September 30, 2014.

<http://www.utrc2.org/research/projects/high-visibility-reflective-sign-sheeting>

From the project description: In many locations in New York State, particularly in and around New York City (New York State Department of Transportation [NYSDOT] Region 11), overhead guide signs are illuminated by NYSDOT with external lighting systems in order to ensure sufficient visibility, even though NYSDOT also uses retroreflective materials in all of its signs. External sign lighting systems entail high installation and operating costs, require difficult maintenance especially in urban locations with high traffic densities, and can contribute to light pollution. Expected results of the project are specification and measurement procedures to ensure that retroreflective signs meet meaningful visual performance criteria, both upon initial installation and after periods of use in the field. Sponsor: New York State Department of Transportation.

Impacts of State DOT Changes to Sign Lighting Policy

Press releases from Hawaii and Illinois DOTs highlight cost savings expected by not lighting overhead signs, and a North Carolina DOT publication estimates cost savings associated with removing existing sign lighting.

Hawaii

“Energy Efficient Highway Signs to Save Thousands of Dollars Every Year,” news release, State of Hawaii Department of Transportation, August 7, 2008.

<ftp://ftp.dot.state.fl.us/lts/co/construction/RetroreflectivityPresentations/Hawaii%20DOT%20Light%20Out%20Press%20Release.pdf>

Highlights from the news release: Installation of high-performance retroreflective sign sheeting on signs without sign lighting along the Moanalua Road corridor is expected to not only reduce energy costs, but will also eliminate maintenance work on the existing overhead light bulbs. Long-term electrical savings are estimated at \$14,000 a year. Maintenance work that goes into replacing the overhead light bulbs is estimated at \$30,000 a year. That figure does not include user costs and inconvenience because during the maintenance work, the DOT issues lane closures in order to allow the crews to complete the task.

Illinois

“IDOT Announces New, Reflective Signs to Improve Safety on Illinois Roadways and Save Money,” press release, Illinois Department of Transportation, October 11, 2006.

<ftp://ftp.dot.state.il.us/lts/co/construction/RetroreflectivityPresentations/IDOT%20Press%20Release%20-%20DG3.pdf>

The press release describes cost savings associated with Illinois DOT’s program to switch out all overhead signs on the state’s roadways to use high-performance sign sheeting. As sheeting is replaced, lighting fixtures will be removed. From the press release:

The new signs will be put up, as old ones need to be replaced, so the change over to the more highly reflective sheeting is expected to take at least 10 years. The price tag for upgrading to the new sheeting is an estimated \$74,000 per year. Once the project is complete the state could see savings of nearly \$1 million a year in sign maintenance and energy costs. Currently, IDOT spends about \$310,000 per year in maintaining the existing overhead lighted signs and approximately \$660,000 per year on energy costs to light the signs.

North Carolina

A Vision Set in Motion: 2010 Annual Performance Report, North Carolina Department of Transportation, 2010.

http://www.ncdot.gov/download/performance/10_annual_report.pdf

Page 7 of the PDF (page 13 of the report) includes examples of the agency’s efforts to improve its efficiency and reduce costs. The item below is among three examples cited in the annual performance report:

Began removing sign lighting in approximately 500 overhead sign structures while replacing existing signs using new highly reflective sign sheeting. The statewide replacement project will save about \$750,000 a year in energy costs alone. The cost to replace signs is expected to be recouped in about five years. The sign sheeting has a 12-year warranty, with most signs providing up to 20 years of service life.

Other Publications

“Evaluation of Overhead Guide Sign Sheeting Materials,” Mohammed Said Obeidat, Malgorzata J. Rys, Andrew Rys, *Proceedings of the 2014 Industrial and Systems Engineering Research Conference*.

<http://www.xcdsystem.com/ie2014/abstract/finalpapers/I606.pdf>

Researchers conducted a field experiment to compare three types of sign sheeting—Engineering Grade, Diamond Grade and High Intensity—to determine the sign sheeting material that best improves sign visibility. The low beam of a vehicle’s headlights was divided into 16 brightness levels and, at each level, illuminance was measured on a sign. Based on a statistical analysis, the Diamond Grade (Type XI) sign sheeting enables drivers to read a sign’s legend from a longer distance, followed by the High Intensity (Type IV) and Engineering Grade (Type I).

“Assessment of Background Complexity of Overhead Guide Signs: Image Processing of Digital Images of Nighttime Roadway Scenes,” Hancheng Ge, Yunlong Zhang, Jeffrey D. Miles, Paul J. Carlson, *Transportation Research Record 2384*, pages 74-84, 2013.

<http://dx.doi.org/10.3141/2384-09>

From the abstract: Researchers have developed a systematic method of using image-processing techniques to assess the complexity of the background of overhead guide and street

name signs under nighttime driving conditions. ... The researchers combined these factors with ratings of images by human survey participants to develop a multiple linear regression model that could be used by practitioners to evaluate the background complexity of overhead guide and street name signs under nighttime conditions. ... Practitioners can use this model to identify overhead guide and street name signs that have highly complex backgrounds and may require sign lighting, supplemental signs, or relocation to minimize driver difficulty in detecting and obtaining information from the signs.

“Legibility of Urban Highway Traffic Signs Using New Retroreflective Materials,” John D. Bullough, Nicholas P. Skinner, Conan P. O’Rourke, *Transport*, Vol. 25, Issue 3, pages 229-236, 2010.

<http://www.tandfonline.com/doi/abs/10.3846/transport.2010.28#.U3OOvVJOW70>

From the abstract: Unlighted highway signs, which use newly developed retroreflective materials, were installed along the major expressway in an urban area by the local department of transportation. Photometric measurements of the signs were used to assess their legibility applying the relative visual performance model, in comparison to lighted signs, conforming to recommended illumination practices. The calculated visibility of the measured unlighted signs was similar to that of the signs equipped with exterior sign illumination. The practical significance and limitations of the relative visual performance approach are discussed.

Survey Results & Analysis for JTC on Roadway Lighting—Survey of AASHTO Members December 2010, AASHTO Joint Technical Committee on Roadway Lighting, May 11, 2011.

<http://scote.transportation.org/Documents/JTC%20on%20Roadway%20Lighting%20-%20survey%20results-April%202011.pdf>

This report details the 36 completed responses to a survey about the sign lighting practices of state DOTs. Twenty-one of the 36 respondents report deactivating sign lighting of existing signs. Thirty of 35 respondents do not use additional lighting in the design of new projects.