Sign and Pavement Marking Retro-Reflectivity Standards

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Retroreflectivitiy Standards for Traffic Signs and Pavement Markings

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Retroreflectivity is a big word with an important job: Keeping the night-time driver on the road! Crash statistics show that the portion of the fatalities that occur at night is significantly higher than what would be expected based on the percentage of miles that are driven at night. Although there are many factors influencing this statistic, providing drivers with the visual cues they need at night is recognized as being essential to highway safety. Retroreflective pavement markings and signs work with vehicle headlights to provide drivers the information they need at night to stay in their lane, to know when to turn, and to be warned of hazards. The ability to measure retroreflectivity, how much light is being reflected back to the vehicle, gives road agencies necessary information on whether drivers are being provided adequate night-time guidance. *So how much retroreflectivity do drivers need? How should it be measured? And should there be minimum requirements?*

These questions have been the subject of significant research and debates for the past 20 years. The U.S. Congress played a significant role when they required FHWA to "revise the Manual on Uniform Traffic Control Devices (MUTCD) to include a standard for minimum level of retroreflectivity that must be maintained for traffic signs and pavement marking which apply to all roads open to public travel" in the 1993 USDOT Appropriations Act. Other key players have included researchers and practitioners who have tried to answer the above questions.

The task of developing national minimum standards is not simple one. Each of the traffic control devices, signs and markings, have several variables that contribute to the needs of the driver (e.g. color, material, size, roadway speed). The driver needs, themselves, vary depending on the driver's physical and mental capabilities, and the vehicle dynamics (particularly headlights and the angle between the driver-device-headlight). Measuring retroreflective properties also has many problems, including inconsistent materials which require the averaging of many data points, equipment that can safely collect and accurately analyze the data, and calibration at a national level. A large number of agencies will be affected by the standards. Some of the effects that need to be considered include the ability of all these agencies to find the resources to measure their inventory, maintain minimum standards, and deal with the potential liability.

Night Time Crash Statistics and Causes

In 1998, over 18,000 fatal crashes occurred during night time conditions[1] (including dawn and dusk). This is nearly 50% of the total fatal crashes, yet it is estimated that only about 25% of the mileage driven is at night. There are many reasons why night time crashes are over-represented including fatigue, inclement weather and a higher percentage of drivers under the influence of drugs and alcohol. We can't solve any of those problems from an engineering perspective, but

[1]U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998*, Washington, D.C., 1998.

we can provide visual cues to help **all** drivers remain on the road and in their own lane. There are many visual cues during the daytime, including guardrail, vegetation, and texture/color variations which make the driving task easy. Most of these visual cues disappear at night. Unless the roadway is lighted, only lighted signs and retroreflective signs and pavement markings remain, so they become critical to the driving task. Even these can become inconspicuous or illegible for a variety of reasons such as competition with internally lighted signs in urban areas, wear of markings from plows and sand, and deterioration of retroreflective qualities.

Defining and Measuring Retroreflectivity

Retroreflected light is that which is sent back to the source. This is the light that is useful to the driving task since it allows the use of vehicle headlights to get the message back to the driver. The amount of light retroreflected depends on the surface the light is reflected off. Light reflected off a common surface like pavement is diffused, so very little light returns to the source. The specular reflection that occurs on mirrored surfaces sends the light off at an equal and opposite angle, returning none to the source. To get retroreflection, the concepts of specular and diffuse reflectivity are used to engineer the surface of signs and markings to maximize the retroreflectivity. For pavement markings, the shape of the glass beads sends much of the light (which actually is refracted off the lower back side of the bead and diffused off the pigmented binder) back toward the light source. Some signs also use beads placed in front of a mirrored surface while others use prisms. The prisms use specular reflection in a way that efficiently returns the light to its source.

Past, Present, and Future of Retroreflectivity Research and Standards

The concept of retroreflectivity requirements is not new. As early as 1942 the MUTCD *discussed* reflectorized devices. The 1954 MUTCD *required* that devices be reflectorized and that requirement remains in the current version. Many agencies do have specifications that require certain minimum reflectivity levels on traffics signs that are to be newly installed, but there have never been standards for minimum in-service values.

There have been significant research efforts since the early 1980's on both the needs of the driver and the economic and practical implications of implementing minimum standards. In one of these efforts, FHWA developed the Computerized Analysis of Retroreflective Traffic Signs (CARTS), a three-stage model for analyzing sign retroreflectivity needs. The model calculates the minimum required visibility distance, sign luminance required at that distance, then converts the luminance to an equivalent retroreflectivity value. Outputs from this model were used by researchers to design a framework for minimum retroreflectivity values and propose guidelines in a 1993 research report.[2] The results are not a single number, there are separate tables for regulatory, warning, and guide signs; and the values differ depending on the sign size, material, roadway speed, and location of the sign (ground-mounted vs overhead). FHWA followed up on

[2]J.F. Paniati and D.J. Mace, *Minimum Retroreflectivity Requirements for Traffic Signs*, Report No. FHWA-RD-93-077, Federal Highway Administration, Washington, DC, 1993.

this with an evaluation study[3] in 1995 which found that the recommended values would accommodate approximately 90 % of drivers for the signs they tested, which included a variety of regulatory, warning and guide signs.

There have also been studies done on the costs of implementing minimum retroreflectivity requirements. One that looked at signs is NCHRP-346.[4] This study used two different minimum retroreflectivity values for each sheeting color, an upper and lower value from those provided by FHWA. Based on the lower value and a 5- to 10-year implementation schedule, the study showed costs would not exceed current expenditures. Based on the higher value, however, they estimated a cost of approximately $156 per year for a 10-year implementation program. A more recent study[5] found costs of about $32 million for State agencies (5% of their signs) and $144 million for local agencies (8% of their signs).

Measuring retroreflectivity of pavement markings is more complex than signs due to all the variables involved in the surface. Besides the actual material differences (e.g. color, paint, thermal plastic, methylmethacrylate, etc.) the surface to which the marking is applied can vary drastically from concrete, to open-graded asphalt, to chip seal. Another issue for agencies trying to manage their inventory is that markings deteriorate relatively quickly and in a less predictable manner than signs.

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[3]Carole J. Simmons and Jeffrey F. Paniati, "Developing Minimum Retroreflectance Values for In-Service Traffic Signs," *1995 Compendium of Technical Papers*, Institute of Transportation Engineers, Washington, DC, August 1995.

[4]K.L. Black , H.W. McGee and S.F. Hussain, *Implementation Strategies for Sign Retroreflectivity Standards*, NCHRP Report 346, Transportation Research Board, National Research Council, Washington, DC, April 1992.

[5]Hugh W. McGee and Sunil Taori, *Impact to State and Local Agencies for Maintaining Traffic Signs Within Minimum Retroreflectivity Guidelines*, Report No. FHWA-RD-97-053, Federal Highway Administration, Washington, DC, 1997.

State Highway Agencies have completed various field studies of existing retroreflectivity levels. One such study[6] shows the retroreflective values and deterioration over a winter for several types of marking materials in Minnesota and Iowa. The study showed that white markings generally have a higher retroreflectivity than yellow markings, and that durable marking materials generally have a higher retroreflectivity than paint. It also found a 15% to 34% deterioration over one winter.

In addition to the research on needs and costs, research has been done on both handheld and mobile retroreflective measuring devices for both pavement markings and signs. FHWA developed and demonstrated vans equipped to take pavement marking retroreflectivity readings at highway speeds in 1995. Similar vans to take readings for signs are currently under development and expected to be demonstrated this summer.

A final rule revising the MUTCD to include a standard for minimum level of retroreflectivity is still some way off.. In 1998, AASHTO requested that FHWA cease rulemaking activity until an AASHTO Task Force could be put together to make recommendations to FHWA. AASHTO's "Task Force on Retroreflectivity Guidelines" was established in early 1999 and is currently reviewing available research. In addition, FHWA has conducted workshops designed to solicit feedback from practitioners on the research results. Three sign workshops were held in 1995 and three pavement markings workshops were held in 1999. The suggestions from these workshops will be used along with the AASHTO Task Force's recommendations in revising the proposed research values. The typical rulemaking process will be followed with the proposed values published in a Notice of Proposed Rulemaking in the Federal Register, comments will be analyzed, then the Final Rule will be published in the Federal Register amending the MUTCD. "A Final Rule could be issued in 2000 for signs and 2001 for pavement markings. The rules will address plans to implement minimum maintained levels of retroreflectivity for each."[7]

Concluding Thoughts

Minimum standards will likely improve the quantity and quality of visual cues for drivers on the nations surface transportation system which will ease the night time driving task and may lead to less night time crashes. On the other hand, it may lead to increased night time speeds and possibly increased amount of night time driving, which may have detrimental effects to safety.

The liability issue will in all likelihood be tested fairly soon after the standards are in place, so it will be critical for agencies to have a management/maintenance system in place to show that they are acting responsibly to attain the standards in a cost-effective manner.

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[6] James Migletz, Jerry L. Graham, Karin M. Bauer, and Douglas W. Harwood, "Field Surveys of Pavement-Marking Retroreflectivity," *Traffic Flow and Safety in Work Zones, Signing, and Marking Materials*, Transportation Research Record No. 1657, Transportation Research Board, National Research Council, Washington, DC, 1999.

[7] Patrick Hasson, "Bringing the Nighttime Road to Life," KUTC Newsletter, Summer 1999.

Summary

Statistics show that there is a night time crash problem. Retroreflective traffic control devices will help to solve this problem by reducing driver error. Research has raised many issues and resulted in proposed values which will be revised in the near future. It is reasonable to expect that a future version of the MUTCD will include a standard for minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings. These minimum levels should not be considered the goal, the goal is increased night time visibility.