Tech Topic

Sign Retroreflectivity

The Federal Highway Administration (FHWA) has enacted changes to the Manual on Uniform Traffic Control Devices (MUTCD) that require new retroreflectivity (a measure of a sign's ability to be read by sensitive driving populations during nighttime and other non-optimal conditions) maintenance standards for signs. Since the MUTCD applies to "any street, highway, or bicycle trail open to public travel," local governments should begin preparing for compliance now. By January 2012, local jurisdictions must establish and implement a sign assessment or a sign management method and all regulatory, warning, and ground mounted signs must be in compliance by January 2015.

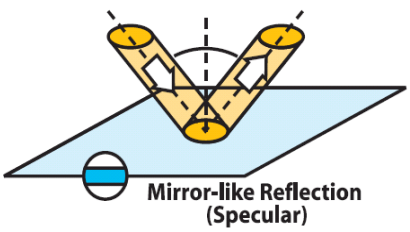
The importance of sign retroreflectivity is seen in these two photographs of the same sign array during the day and then again at night. Notice the variable clarity of the different signs and how one sign has disappeared altogether.

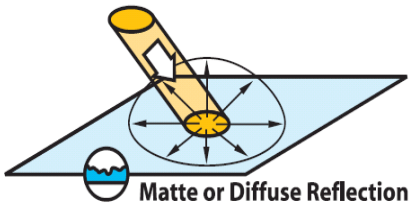
Retroreflectivity is often confused with reflectivity and, indeed, transportation professionals commonly apply the second term incorrectly. And, for our purposes, the difference matters.

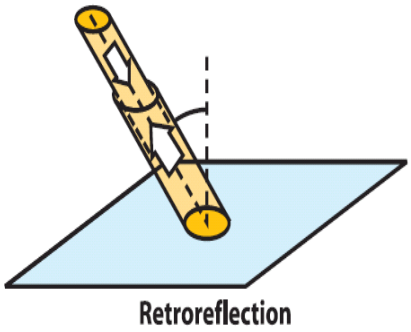
For many, the figures below help de-mystify this cumbersome word that we in the transportation arena have begun to hear at every turn. In this context, light can reflect in three primary ways. The first is the very familiar mirror reflection—if we look directly perpendicular at a mirror surface we see ourselves, but if we look at an angle, we see those objects to the left or the right, up or down. The light source does not return to the source; instead it bounces at an angle equal to the angle it entered the mirror surface.

Diffuse reflection is a phenomenon of light when it hits a matte or dull or other less than reflective surface and, instead of reflecting, tends to scatter or diffuse. For example, we would not see our reflection if we looked into the vinyl siding of our house.

Neither of these reactions is helpful to us for seeing traffic signs at







night. That is why sign sheeting materials are designed to be retroreflective, wherein the light source (in this case, from our headlights) is reflected back along the same axis with a minimum of scattering. This allows the sign to be located safely out of the line of travel and yet be visible at night.

The importance of sign retroreflectivity can be seen again in the photographs below. The chevron signs along this harsh curve are only one of the several visual clues the driver has during the day, when the guardrail, the pavement markings, and the vegetation beyond the curve all provide indications of the curve. But at night on this same curve, only the chevrons remain as visible evidence. Imagine if one or more had poor retroreflectivity and you were a stranger to this curve.

Because of an increasing older driver population in the United States, the MUTCD includes new standards for minimum retroreflectivity levels for most signs. The first compliance date is January 2012, when all state and local agencies must adopt and implement a management or maintenance method (or combination of methods) for sign retroreflectivity. These can be selected from the following:

- Visual Nighttime Inspections. Each of these three methods requires that trained inspectors conduct visual inspections of signs at night at roadway speeds with properly aimed headlamps (low beam).
    - Calibration Signs. Inspectors calibrate their eyes by viewing control signs that are near minimum retroreflective levels and then view roadside signs to spot less retroreflective materials.
    - Comparison Panels. Small sample panels of sheeting material near minimum retroreflective levels are clipped to roadway signs for comparison.
    - Consistent Parameters. A trained inspector greater than 60 years old travels the roadways in an SUV type vehicle with "cut-off" headlamps; this is the method used to establish the minimum retroreflective levels in the supporting research.
- Measured Sign Retroreflectivity. A specialized instrument called a retroreflectometer is used to directly assess a sign for compliance.
- Expected Sign Life. Using various measures of demonstrated sheeting life, signs are replaced when they reach

a certain age, usually through the use of stickers placed on the back of the signs.

- Blanket Replacement. This is similar expected sign life, except that individual signs are not tracked; instead whole groups of signs are replaced based on location or type of sign.
- Control Signs. Groups of representative signs are arranged in a controlled location representative of the in-service location of similar signs; the control signs are measured for retroreflectivity periodically and when they near minimum retroreflective levels, their in-service companions are replaced.
- Future Methods Based on Engineering Study. Consideration was made that other methods might yet be proven in engineering studies.

- Combination of any of the above. The MUTCD permits the combination of these methods in any responsible program that reasonably assures compliance.

The new minimum retroreflectivity levels are shown below (Table 2A-3 from the MUTCD). For the uninitiated, this table appears complicated, with specialty jargon that is unfamiliar. But with a minimum of training, the requirements will be significantly less foreign for most people. For example, the "white on green," "black on orange," etc. sign colors become instantly recognizable by looking at the examples on the next page.

New MUTCD Table 2A-3. Minimum Maintained Retroreflectivity Levels (1)

Sign Color	Sheeting Type (ASTM D4956-04)				Additional Criteria
	Beaded Sheeting			Prismatic Sheeting	
	I	II	III	III, IV, VI, VII, VIII, IX, X	
White on Green	W*; G ≥ 7	W*; G ≥ 15	W*; G ≥ 25	W ≥ 250; G ≥ 25	Overhead
	W*; G ≥ 7	W ≥ 120; G ≥ 15			Ground-mounted
Black on Yellow or Black on Orange	Y*; O*	Y ≥ 50; O ≥ 50			(2)
	Y*; O*	Y ≥ 75; O ≥ 75			(3)
White on Red	W ≥ 35; R ≥ 7				(4)
Black on White	W ≥ 50				—

1 The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m2 measured at an observation angle of 0.2 ° and an entrance angle of -4.0 °.
2 For text and fine symbol signs measuring at least 1200 mm (48 inches) and for all sizes of bold symbol signs
3 For text and fine symbol signs measuring less than 1200 mm (48 inches)
4 Minimum Sign Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)
* This sheeting type should not be used for this color for this application.

Bold Symbol Signs		
• W1-1, -2 – Turn and Curve • W1-3, -4 – Reverse Turn and Curve • W1-5 – Winding Road • W1-6, -7 – Large Arrow • W1-8 – Chevron • W1-10 – Intersection in Curve • W1-15 – 270 Degree Loop • W2-1 – Cross Road • W2-2, -3 – Side Road • W2-4, -5 – T and Y Intersection • W2-6 – Circular Intersection	• W3-1 – Stop Ahead • W3-2 – Yield Ahead • W3-3 – Signal Ahead • W4-1 – Merge • W4-2 – Lane Ends • W4-3 – Added Lane • W4-6 – Entering Roadway Added Lane • W6-1, -2 – Divided Highway Begins and Ends • W6-3 – Two-Way Traffic • W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning • W11-2 – Pedestrian Crossing	• W11-3 – Deer Crossing • W11-4 – Cattle Crossing • W11-5 – Farm Equipment • W11-6 – Snowmobile Crossing • W11-7 – Equestrian Crossing • W11-8 – Fire Station • W11-10 – Truck Crossing • W12-1 – Double Arrow • W16-5p, -6p, -7p – Pointing Arrow Plaques • W20-7a – Flagger • W21-1a – Worker

Fine Symbol Signs – Symbol signs not listed as Bold Symbol Signs.

Special Cases

- W3-1 – Stop Ahead: Red retroreflectivity ≥ 7
- W3-2 – Yield Ahead: Red retroreflectivity ≥ 7; White retroreflectivity ≥ 35
- W3-3 – Signal Ahead: Red retroreflectivity ≥ 7; Green retroreflectivity ≥ 7
- W3-5 – Speed Reduction: White retroreflectivity ≥ 50
- For non-diamond shaped signs such W14-3 (No Passing Zone), W4-4p (Cross Traffic Does Not Stop), or W13-1, -2, -3, -5 (Speed Advisory Plaques), use largest sign dimension to determine proper minimum retroreflectivity level.

In representative samples of street signs in Delaware, it is not unusual to find a third or more near or less than minimum retroreflective levels that will become effective January 2012. Stop signs are particularly troublesome, in that they tend to "wash out," a condition where the red overlay fades and the white sheeting underneath dominates and even when the levels of both colors remain above minimum, the contrast ratio (3 to 1) specific to white on red signs fails and the sign is in noncompliance. In-service signs with a southern exposure tend to fail sooner as well.

While no one expects that a Federal Highway Administration sign inspector will visit in January 2012, vehicle and pedestrian incidents of minor and grave consequences can happen on any street and tort liability suits often follow. All local agencies would be wise to move towards compliance now, since compliance does have budgetary implications at all levels. The first step is inventory and some form of assessment of a representative group of signs. Then, a method or methods should be chosen and documented and implementation should begin (including documentation). The Delaware T^2 Center can help with training and one on one guidance.

Suggested Further Reading and References:

- Federal Highway Administration MUTCD: http://mutcd.fhwa.dot.gov/pdfs/2003r1r2/mutcd2003r1r2complet.pdf
- FHWA Know Your Retro website: http://safety.fhwa.dot.gov/roadway_dept/night_visib/policy_guide/fhwasa07020/
- ATSSA Retroreflectivity Clearinghouse: http://www.atssa.com/cs/root/retroreflectivity/what_is_retroreflectivity/basics
- Delaware T^2 Center Retroreflectivity Overview (Power Point Presentation): http://www.ce.udel.edu/dct/t2/Technical%20Briefs%20&%20Case%20Studies.htm

The Delaware T^2 Center's full-time Engineer position was established with the primary mission of providing transportation advice and technical assistance to Delaware municipalities. Contact Matt Carter at matheu@udel.edu or at (302) 831-7236 for assistance.