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Uniform-looking signs start with sheeting orientation.

This information is intended for a state agency, traffic engineer or specifier looking for a better understanding of the effect of sheeting orientation on traffic sign performance.

- The agency/engineer/specifier has several choices when developing new standards or specifying and purchasing reflective sheeting for signs. They are looking for guidance as they may find the details about retroreflective sheeting performance technical, complicated and hard to understand. For instance, what attributes of sheeting performance are important to specify?
- Guidance they rely on may come from:
    - Standards, including ASTM D4956 and AASHTO M268 (which has a rotational sensitivity test)
    - Sales reps, who provide information about product details
    - The internet
    - Industry associations
    - Published product brochures from sheeting manufacturers

Executive Summary

All microprismatic sheetings on the market today have some degree of variation in performance as they are rotated on a sign, including prismatic sheeting that meets the AASHTO M268 rotational uniformity test. Unfortunately, meeting this test does not guarantee an orientationally uniform-looking sign legend. Additionally, it may prematurely limit the sheeting designer's ability to address the versatility and performance required in today's challenging sign applications.

3M believes that optimizing the sheeting design for the demands of real-world applications is more important than meeting one benchmark of orientational uniformity at the expense of versatility. For signs where retroreflective uniformity is a concern, 3M recommends adhering to a simple set of sign manufacturing practices. It's the best guarantee that signs are high performing and uniform-looking.

Main Story

Box 1. The direct-applied cut-copy application method.

In a direct-applied cut-copy application, individual letters or sign elements are cut from Prismatic sheeting and applied on top of a strip of background sheeting. If letters and elements are cut out at different sheeting orientations, these will have a different brightness when illuminated at shallow angles of illumination.

Consider a certain state agency/specifier who adopts AASHTO's specification M 268, Section 3, for the fabrication of signs in its region. Sheeting is ordered from a qualified producer and several guide signs are produced using the direct-applied cut-copy application method (Box 1). While the sign fabricator has produced signs in compliance with the AASHTO standard, the signs may appear non-uniform during inspection after installation on the roadway. The state agency/specifier is now facing a challenging situation. They can either accept signs with possibly subpar performance and a potential impact on road safety, or replace the signs, which can lead to increased project costs and delays.

What went wrong? Or, why did the AASHTO specification not guarantee the desirable roadway performance? AASHTO's specification sets a maximum rotational sensitivity requirement for just one condition of sign illumination. On the roadway, drivers encounter many more conditions of illumination, and, under some of these conditions, a change in sheeting orientation can have a great impact.

To help you better understand this, we plotted the retroreflective performance of sheeting products as a function of the illumination angle, and did so separately for sheeting at different orientations (Box 2). The sensitivity to orientation of these products is most apparent at more shallow angles of illumination. Consequently, when letters and sign elements are cut out at different sheeting orientations, these will return light at different levels of brightness, which may reduce the legibility of the sign.

Box 2. How the orientation of sheeting impacts the performance of a sign.

Illuminated head on, or close to head on, a sign made of cube corner microprisms returns a large portion of the incident light back to the driver. Depending on the design and configuration of the microprisms, changing the orientation of the sign may have very little impact on the level of retroreflection. However, when the angle of illumination becomes shallower—as explained in Figure 1—the sign returns a smaller portion of the incident light back to the driver. Moreover, the sign becomes much more sensitive to changes in the orientation of the sheeting, as is shown in Figure 2. Thus, to fabricate a bright and uniform-looking sign, it is critical to apply the sheeting in one of its optimal orientations.

With sheeting at a 0 degrees orientation, 3M sheeting outperforms some competitors who claim orientation does not matter on their sheeting, especially at shallow angles of illumination—shown in Figure 3. This makes the sign in the roundabout video much brighter and visually uniform when 3M sheeting is applied to it using the recommended orientation of 0 degrees.

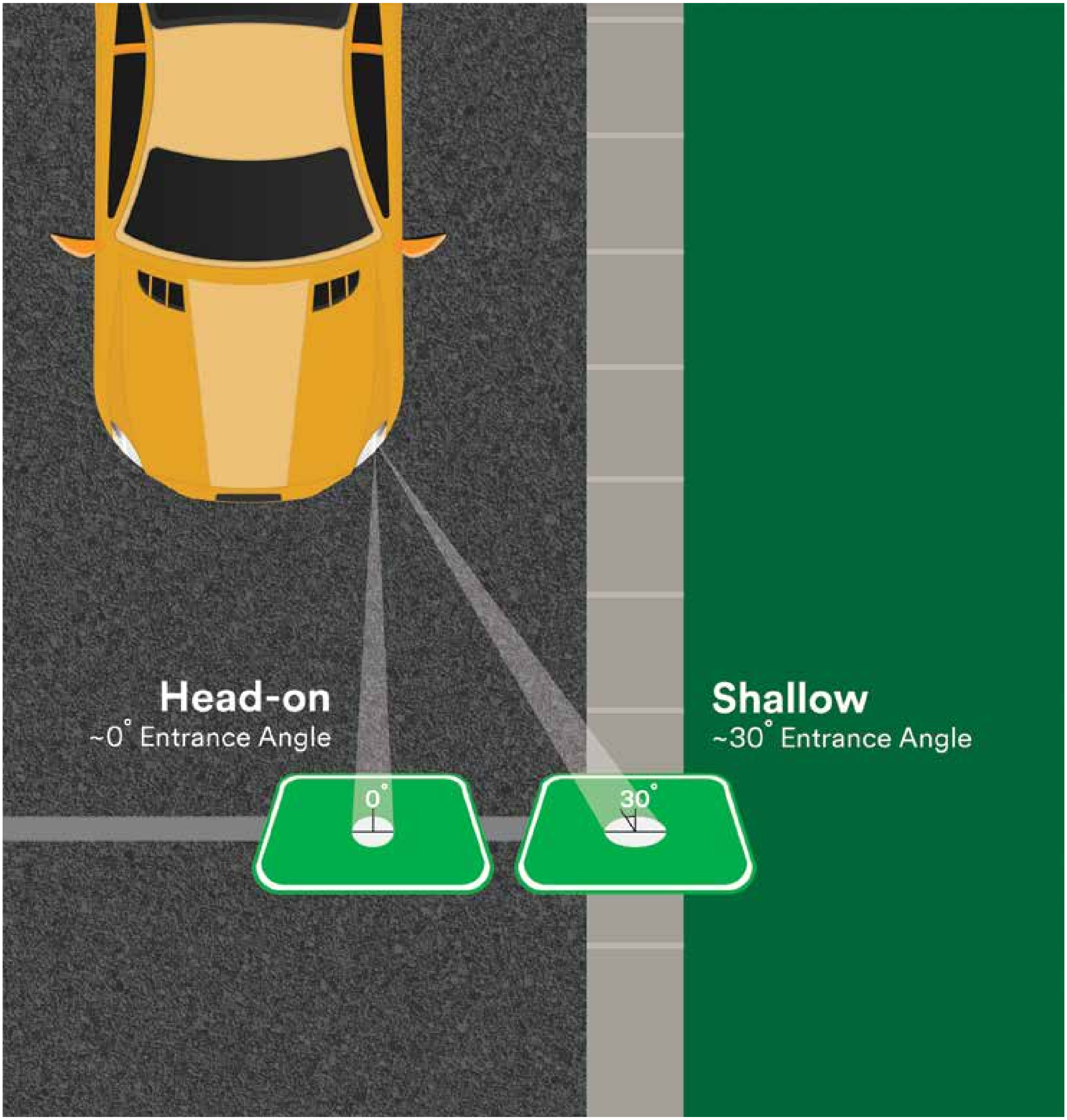


Figure 1.

Explaining how differences between head-on and shallow illumination relate to the entrance angle used to classify sheeting. When a sign no longer faces the light source, illumination has become shallow and light enters the sign at a larger angle. The values of the entrance angles are for illustrative purposes, not exact.

Prismatic Sheeting is not Orientationally Uniform

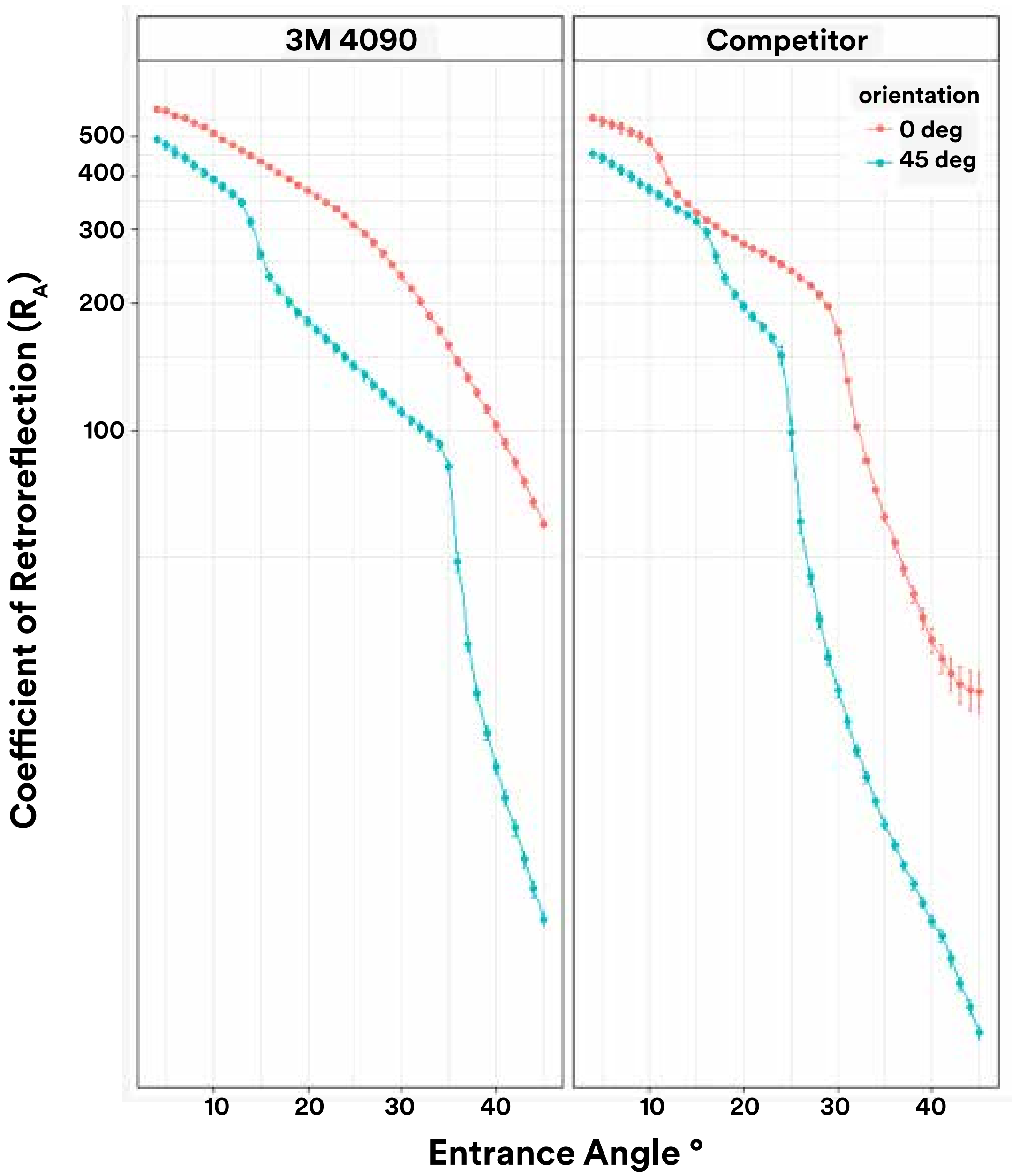


Figure 2.

The retroreflective performance (R_A) plotted for sheeting at two different sign orientations, with different panels for sheeting from 3M and a competitor. Variation in performance—as in the gap between the two lines—is present for both prismatic sheetings, and more so for shallow illumination at larger entrance angles. The scale on the y-axis is plotted on a logarithmic scale, consistent with the human ability to perceive increases in brightness. The luminance data are obtained for sheeting at a 0.5 degrees observation angle as per ASTM E810 method by an independent third-party test facility.

3M Sheeting is Brighter at All Entrance Angles Tested

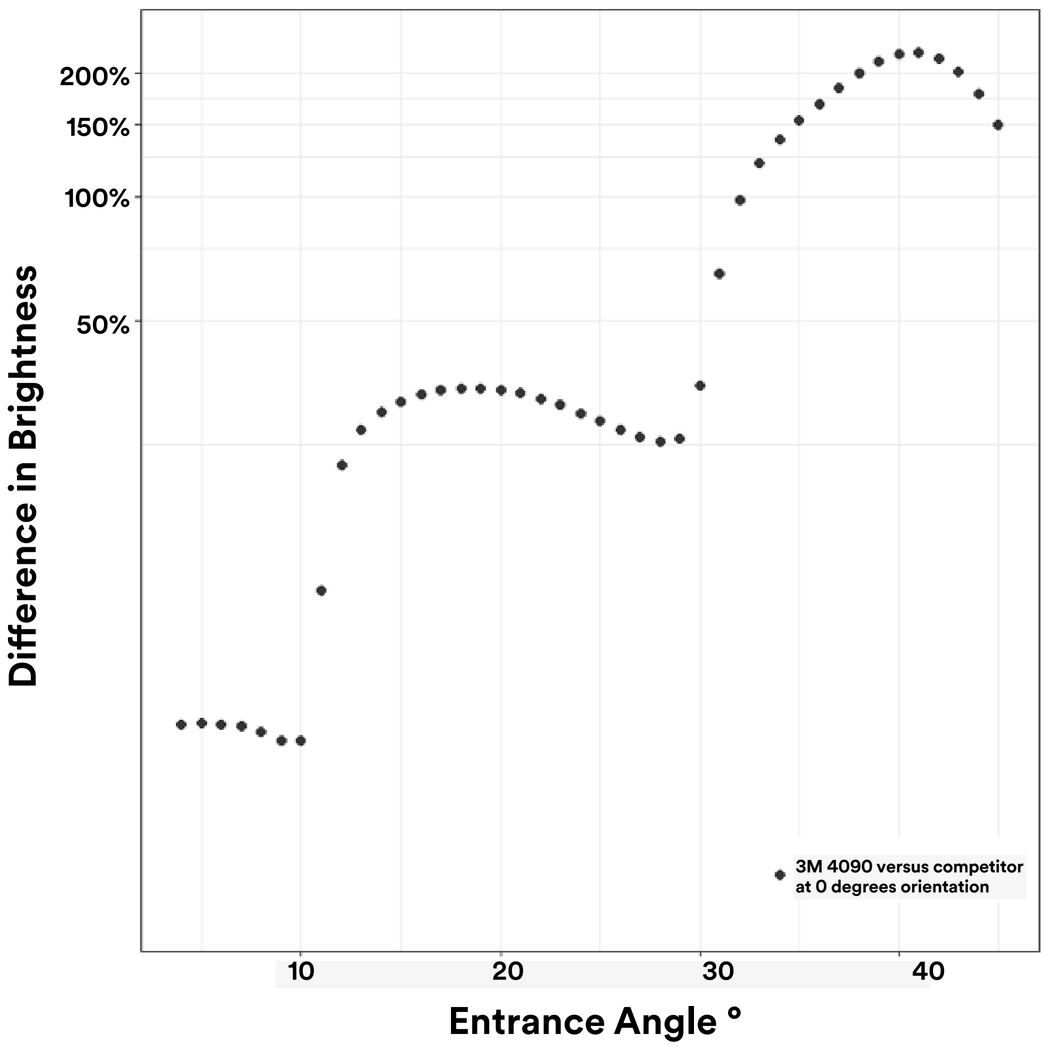


Figure 3.

The difference in retroreflective performance between 3M and a competitor sheeting at a 0 degrees orientation – contrasting the two red lines from Figure 2. The luminance data are obtained for sheeting at a 0.5 degrees observation angle as per ASTM E810 method by an independent third-party test house.

In light of the above, what can the specifying agency do to best manage the fabrication of uniform-looking signs by direct-applied cut-copy method? The agency should specify that sheeting elements of the same color are oriented uniformly on a sign. 3M, recommends that sheeting is applied at either (optimally) 0 degrees or at 90 degrees. This ensures that the microprisms can perform in their optimal, or close to best, orientations (Box 3). This recommendation is consistent with AASHTO M-268 Sections 3.3.1 and 3.3.2—that the sheeting of cut copy sign elements must be applied at the optimal orientation onto background sheeting that is uniformly oriented.

Finally, it is important to keep in mind that cut-copy is one of several sign fabrication methods. 3M is not in favor of subjecting all sheeting to a design requirement that is meaningless for most signs. Doing so may compromise the sheeting's versatility and prematurely limits the full-potential offered by microprismatic optics, as illustrated in Figure 3.

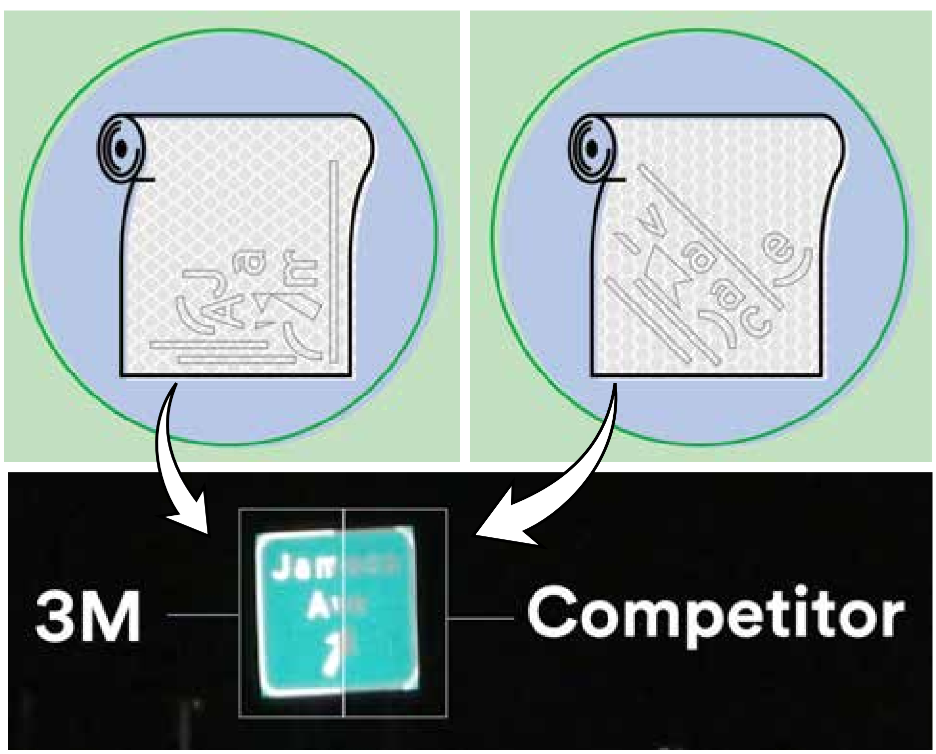
Box 3. Fabricating a uniform-looking sign: orientation does matter.

We built a sign using sheeting materials of competing sheeting products per their specific fabrication directions (Figure 4). While competitive sheeting product meets AASHTO's requirement of maximum rotational sensitivity, using this as a criterion for purchasing purposes, one would have eliminated the sheeting materials used to fabricate the better-looking half of the sign (left). Hence, one may end up with a non-uniform looking sign (right), just like in the story above. The sign would have looked much more similar if constructed with sheeting pieces of the same color oriented in a uniform direction.

Watch Video >

Figure 4.

3M™ DG^{3} 4090 ***Competitor Type XI***



3M™ Diamond Grade™ DG^{3} 4090 Type XI Sheeting
Half of the letters (direct applied copy) in the sign shown were produced using 3M™ DG^{3} 4090 Type XI sheeting, using 3M's recommended orientation. The image was taken from the front seat of an SUV and was illuminated using headlights only.

Competitor's Type XI Sign Sheeting
The other half of the letters (direct applied copy) in the sign shown were produced using a competitor's type XI sheeting per their recommended orientation (any).

Conclusion

The AASHTO standard M 268-15, "Retroreflective sheeting for flat and vertical traffic control applications" does not guarantee uniform-looking signs made by cut-copy method. In addition, complying with this one test of rotational uniformity would limit the way a sheeting manufacturer can optimize their design for the full spectrum of signs. To achieve uniform-looking signs with any prismatic sheeting—including those that meet the AASHTO M 268 test— a guaranteed way is to uniformly orient sheeting pieces of the same color. This is built-in and happens by default for most sign fabrication methods. It is only for the signs made by cut-copy method that one should specify an additional instruction that is easy to perform.

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