

accordance with the rule meet all the performance requirements, except for the minimum photometric performance requirements, of ASTM D 4956-01. The minimum photometric performance requirements (*i.e.*, minimum SIA) of the FRA standard are set forth in Table 1 of the proposed rule. The proposed values were developed to perform above the minimum detection threshold of 45 cd/ft<sup>2</sup> identified in the 1999 Volpe Report as necessary to enable most motorists to detect a train in time to avoid a collision. Recognizing that in the real world railroad operating environment, the effective SIA of retroreflective materials depends on various factors (*e.g.*, grade crossing configurations and angles, ambient light conditions, vehicle headlight type and lens cleanliness, weather, and the presence and working condition of illumination and other warning devices) and may be reduced because of accumulated dirt and grime, the proposed minimum photometric performance requirements take into account these varying factors. Specifically, extrapolating the test data detailed in the Volpe Report out ten years, the manufacturers' stated useful life of the material, FRA found that the forecasted SIA levels remained well above the minimum detection level established in the 1999 Volpe Report. In addition, although the primary degradation in the SIA of the material occurs during the first two years as a result of ultraviolet light exposure, after which the material maintains a relatively consistent intensity throughout its useful life, FRA forecasted SIA degradation of the material due to dirt and grime accumulation exponentially. As a result, FRA's analysis substantially overestimates the degradation rate of the material and even with this overestimation, the expected SIA values remain well above the minimum detection level identified in the 1999 Volpe Report.

Table 1 specifies the minimum photometric performance requirement (*i.e.*, minimum required SIA) for yellow retroreflective material at observation angles of 0.2° and 0.5° and light entrance angles of -4° and 30° based on ASTM D 4956-01. FRA's Grade Crossing Inventory identifies crossings into three categories of crossing angles: 60-90°, 30-59°, and 0-29°. Approximately 80% of all crossings have crossing angles between 60 and 90°, almost 17% have crossing angles between 30 and 59°, and only 4% have crossing angles less than 30°. Accordingly, the requirements of Table

1 ensures that the retroreflectors will perform above the minimum detection threshold for the average motor vehicle at approximately 97% of all crossings.

Although the minimum photometric performance requirements set forth in the proposal are specific to yellow microprismatic retroreflective material, FRA recognizes that many car owners who currently reflectorize their cars have used white microprismatic retroreflective material. If FRA alternatively required the use of white retroreflective material, the minimum photometric performance requirements (based on a required detection distance of 500 feet) for the retroreflective material would be as follows:

Entrance angle	Observation angle	
	0.2°	0.53°
-4° .....	600	160
30° .....	350	75

Minimum Photometric Performance (Coefficient of Retroreflection ( $R_A$ ) in Candela/Lux/Meter<sup>2</sup>) Requirement for White Retroreflective Sheeting.

FRA requests commenters' views as to the desirability of using white versus yellow retroreflective material and further solicits comments and alternative suggestions to the proposed construction, color, and performance requirements of this section.

The responsibility for compliance with the construction, color, and performance requirements of the retroreflective sheeting used to comply with this rule would rest upon the manufacturers of the sheeting. Thus, manufacturers who are providing retroreflective sheeting to the railroad industry would have to certify compliance with § 224.103. Paragraph (d) sets forth this certification requirement and would require that the characters "FRA-224" be permanently stamped, etched, molded, or printed, in characters at least 3 mm high, with each set of characters spaced no more than four inches apart, on each piece of retroreflective sheeting manufactured.

Although, the proposed rule generally requires application of retroreflective sheeting meeting the specific construction, color, and performance requirements of § 224.103(a) through (c), paragraph (e) of this section recognizes that under § 224.15, freight rolling stock owners and railroads may request FRA approval to use alternative standards. As discussed in the analysis of § 224.15 above, any alternative standard utilized must result in an equivalent level of safety as the sheeting described in 224.103(a) through (c) applied in accordance with the rule.

#### Section 224.105 Size and Location

This section proposes to make the amount and placement of retroreflective sheeting required to be applied to freight rolling stock pursuant to this part dependent on the size of the car or locomotive, as well as the car type. A primary concern in developing the proposed standards of this part was developing a retroreflective pattern that is detectable in time for an approaching motorist to recognize a train in the grade crossing and respond appropriately in time to avoid an accident. Another concern was the potential for motorist confusion as more potential roadway hazards (particularly truck trailers) benefit from the addition of reflectorization. Accordingly, recognizing that a unique, uniform pattern of application is necessary to facilitate recognition of rail cars and that the placement of retroreflectors affects their performance, this section proposes a specific pattern of application, striving to achieve as uniform a pattern as possible throughout the relevant fleet, while taking into consideration the configurational differences between various types of freight rolling stock. Although a vertical pattern of retroreflective material along the entire side of freight cars is proposed, FRA recognizes that the physical configuration of locomotives and the conspicuity issues surrounding locomotives are different. Accordingly, in paragraph (b) of this section, FRA proposes a more flexible approach to the reflectorization of locomotives.

As discussed earlier in the preamble, the general consensus of research pertaining to retroreflective materials is that retroreflective materials can increase the conspicuity of objects to which they are attached. FRA, however, found little existing research that suggested how retroreflective materials should be displayed on rail cars to maximize the conspicuity of the cars for approaching motorists. Early studies suggested that massed applications (concentrating retroreflective material in one or two locations) were more effective than those applications that were distributed over a wider area. More recent studies assessing the effectiveness of retroreflective markings on trucks used the newer prismatic materials and concluded that providing a design that outlined the shape of the vehicle increases conspicuity.

The recommendation to use an outline shape was based in part on the need of a motorist to estimate closing distance when following behind a truck. However, motorists' interaction with trains is different from trucks. Because