

property damages which result from those collisions. FRA's Preliminary Analysis concluded that the benefits of a uniform, nationwide freight car reflectorization program would far outweigh the costs of such a program.

In the Preliminary Analysis, FRA identified the primary source of benefits to be gained from freight car reflectorization as the avoidance of a portion of the fatalities, injuries, and property damage that result from collisions between motor vehicles and freight trains at grade crossings. Statistics show that collisions between trains and motor vehicles often result in fatal or very serious injuries to the occupants of the motor vehicle involved, and the vehicle may be completely destroyed. In addition, collisions between trains and motor vehicles often result in damage to the rail equipment and significant delays and disruptions to rail operations. For example, FRA's Railroad Safety Advisory Committee estimates that collisions cause an average of a two-hour train delay at \$250 per hour for freight trains. This estimate does not include the ripple effect of delays incurred by other trains, including passenger trains, awaiting use of the track where service has been interrupted.

FRA calculated the expected safety benefits of reflectorization in terms of the decline in the probability of RIT accidents. Recognizing that the effectiveness of retroreflectors (and therefore the benefits to be gained from their use) will vary by circumstance (e.g., nighttime versus daytime conditions, clear versus cloudy weather conditions, presence of other warning devices at a crossing, train speed and length, etc.), FRA's Preliminary Analysis recognized that forecasting the benefits which would likely result from reflectorization necessitated a certain amount of subjective analysis and the exercise of judgment. Accordingly, based on the manufacturers' 10-year guaranteed useful life of retroreflective sheeting, FRA employed four different approaches to the estimation of benefits. Benefit estimates were based on varying effectiveness rates derived from (1) two previous studies analyzing the effectiveness of reflective material on large trucks, (2) subjective estimates of reflector effectiveness by internal FRA grade crossing experts, and (3) a signal detection model consisting of an analysis of the statistical probability of different potential severities of hazard or injury, based on laboratory experiments and accident/incident data from FRA's Rail Accident/Incident Reporting System database. FRA

estimated the ten-year discounted benefits of a reflectorization program, in terms of avoided casualties and property damage, to be in the range of \$57 million, \$70 million, \$100 million, or \$105 million, depending on the methodology employed.

Taking into consideration material, installation and maintenance costs, FRA's Preliminary Analysis concluded that over a ten-year period (the estimated useful life of the retroreflective material), the discounted cost to reflectorize the entire freight railroad fleet would be approximately \$40 million. Accordingly, FRA concluded that the reflectorization of railroad freight equipment is a viable and cost-effective method of reducing the number of collisions at highway-rail grade crossings and the casualties and property damages which result from those collisions. FRA published the results of its Preliminary Analysis on October 26, 2001. See 66 FR 54326. A copy of the Preliminary Analysis is in the docket of this proceeding. (Document No. FRA-1999-6689-25).

Because of the rail industry's continued interest in the issue of rail car reflectorization, FRA met with members of the regulated community on March 24, 2003, to again listen to their comments and concerns regarding reflectorization. During this meeting, the participating railroads and car owners reiterated their concerns regarding a potential rail car reflectorization rulemaking. Specifically, participants expressed concern that a federal rulemaking mandating reflectorization could have the effect of increasing their liability for grade crossing accidents. Participating railroads and car owners also raised important considerations regarding many practical aspects of a potential reflectorization program (e.g., a feasible schedule for the application of reflectors to rail cars, what types of reflective material would be required, reflector cleaning and maintenance responsibilities, and when and where reflectors would be applied to cars).

B. Fundamentals of Reflectivity and Human Eyesight

Materials that have reflective properties can be classified into three general categories: direct reflectors, diffuse reflectors, and retroreflectors. Direct reflectors, such as mirrors, bounce light off the reflective material at an angle equal and opposite to the direction of the light source. Diffuse reflectors, such as license plates, bounce light off the reflective material at an angular spread of up to 180 degrees. Retroreflectors, however, direct the reflected light in the direction of the

light source. As applied to motorists approaching grade crossings, retroreflective material on the sides of rail cars will reflect light from an approaching vehicle's headlights back to the motorist in a concentrated beam. If either a direct or diffuse reflective material was applied to the sides of rail cars, light from an approaching vehicle's headlights would be reflected in several different directions, thereby lessening the amount of light reflected back to the motorist.

Retroreflective material is rated in terms of the reflected light per unit area as contrasted with the light striking it ("specific intensity per unit area" or SIA). The amount of reflected light reaching the driver's eyes will determine how bright that object appears to the driver. Therefore, retroreflective materials that are efficient in returning light to a driver's eyes may appear brighter to the driver than materials that are not as efficient. The newest, most durable, and most efficient retroreflective material available today, the prismatic type retroreflector, is made of microscopic prisms or corner cubes. Each of these prisms or corner cubes contains three surfaces oriented at 90 degrees to each other. The entering rays of light are reflected from each of the surfaces and are returned to the observer in a more concentrated and focused beam than direct or diffuse reflectors or even other types of retroreflective material.

The amount of light received by an observer from a retroreflector is affected by six factors: (1) Reflective intensity of the material (the SIA), (2) size of the retroreflector, (3) intensity of the light source (in the case of grade crossings, the intensity of approaching motor vehicles' headlights and the efficiency of those headlights), (4) atmospheric transmissivity (e.g., clear, foggy, or hazy weather conditions), (5) windshield transmittance, and (6) the distance of the observer from the retroreflector. The relationship among these factors and the illuminance received by an observer is based on *Allard's Law* and is represented by the following equation:

$$E_e = \frac{I_s * A * B * t^{2d} * W * H}{d^4}$$

in which

E_e = Illuminance received by the observer (measured in footcandles (fc))

I_s = Intensity of the light beamed toward the reflector (measured in candela (cd))

A = Area of the reflector (measured in square feet)