

drivers become habituated (or pre-conditioned) to the crossings. In other words, based on previous driving experiences and conditioning, a driver may not expect a train to be occupying a crossing, and without a clear auditory signal (because the locomotive has already cleared the crossing) or visual stimuli alerting the driver to a train traveling through the crossing, the driver may fail to perceive the train in time to stop. This condition is further exacerbated when a train is stopped on a crossing.

There is currently no requirement for lighting or reflective markings on freight rolling stock. However, in recognition that the transportation of people and goods is not restricted to daytime hours and pristine weather conditions, reflectorization has become an indispensable tool for enhancing visibility in virtually all other modes of transportation, including air, highway, maritime, and pedestrian travel. For example, airplanes and motor vehicles are equipped with high brightness retroreflective material at key locations on the exterior surfaces to increase their conspicuity. Microprismatic corner cube retroreflectors (which have the ability to direct light rays back to the light source) are typically used on roadway signs that warn of construction or other hazardous conditions. Federal regulations require retroreflective materials on the sides and rear of large trucks to increase their conspicuity and to aid motorists in judging their proximity to these vehicles. Even regulations addressing bicycle safety have specific requirements on the use of reflective materials. Lifesaving marine equipment, such as life vests and rafts, require reflectorization; and to enhance the conspicuity of pedestrians, especially at night, retroreflective material has been incorporated into clothing and similar items.

The everyday use of reflectors indicates their acceptance to delineate potential hazards and obstructions to a vehicle's path of travel. Research specific to the railroad industry has demonstrated that reflective materials can increase the conspicuity of freight cars, thereby enhancing motorists' ability to detect the presence of trains in highway-rail grade crossings. This greater visibility can help drivers avoid some accidents and reduce the severity of other accidents that are unavoidable. Accordingly, FRA, as the Federal agency responsible for ensuring that America's railroads are safe for the traveling public, and in direct response to a Congressional mandate, proposes to require use of reflective material on the sides of certain rail cars and

locomotives to enhance the visibility of trains in order to reduce the number of accidents at highway-rail grade crossings where train visibility is a contributing factor.

#### *A. History of Railroad Car Conspicuity Issue and Congressional Mandate*

As applied to rail car visibility, the term "conspicuity" refers to the characteristic of a rail car in its roadway setting to command the attention of approaching motorists and be recognizable to reasonably prudent motorists at sufficient distance to allow the motorists to reduce their vehicles' speed and take action to avoid collisions. Research relating to the conspicuity of rail cars is not a new concept. Research dating back to the early 1950s has noted the potential viability of rail car conspicuity materials such as luminous sources (lights on rail cars), self-luminous sources (phosphorescent), and reflective sources. In the mid 1950's, researchers concluded that reflective material along the side sill of boxcars increased the visibility of the cars and aided in the perception of the cars' motion. The same study also found that the amount and distribution of reflectorized material proportionally affected the level of visibility and accuracy of perception of rail cars' motion. In other words, by using material with high coefficients of reflectivity (*i.e.*, high levels of reflected light) against a high contrast background (*e.g.*, dark and dirty rail cars), the amount of illumination was increased, and the motorists' ability to discriminate the movement of the rail cars across their line of vision was enhanced. In the early 1970's, a study concentrating on the conspicuity of trains at night found that although luminous and reflective sources both proved effective in enhancing the visibility of trains, reflectors provided conspicuity at a greater distance and field of vision than the other sources which were studied.

The general consensus of historical research was that reflective materials can increase the conspicuity of objects to which they are attached, but previous generations of reflective materials did not reflect enough light to be effective in the railroad environment and lacked the durability to survive the harsh railroad operating environment. For example, in 1959 a Canadian freight car reflectorization program was begun. In this program, high-intensity retroreflective sheeting in the shapes of circular discs and squares were applied to the sides of rail cars for the purpose of assessing their long term durability and performance. Reflective intensity

measurements on the Canadian cars after six months, one year, and two years of service indicated rapid deterioration of the retroreflective material. Only 23% of the material's original reflectivity remained at the end of six months. This declined to 14% after one year and to 5% at the end of two years of service. Tests of similar high intensity retroreflective sheeting conducted by the Boston and Maine Railroad in 1981 yielded substantially the same results as the earlier Canadian tests.

FRA first evaluated the use of reflective material on rail rolling stock in the early 1980s, and supported a study completed in 1982 on the potential use of reflectorization to reduce nighttime accidents at highway-rail intersections. The study concluded that although the use of reflective material enhanced the visibility of trains, the reflective material was not durable enough to withstand the harsh railroad environment. It was decided that rulemaking action was not warranted at that time.

Since 1982, however, improvements in the brightness, durability, and adhesive properties of reflective materials have been achieved and a new material, microprismatic retroreflective material, is now available. Because of the technological advances in reflective materials and the creation of microprismatic retroreflective material, beginning in the early 1990's FRA funded renewed research through the John A. Volpe National Transportation Systems Center in Cambridge, Massachusetts ("Volpe") to reexamine the issue of using reflective material to enhance railcar conspicuity.

In July 1999, FRA announced the results of its renewed research efforts with the release of the report *Safety of Highway-Railroad Grade Crossings: Freight Car Reflectorization* (DOT/FRA/ORD-98/11) ("1999 Volpe Report"). The 1999 Volpe Report provided significant information, including cost estimates and data on the performance of equipped rail car fleets in an actual service environment. Similar to earlier research, the 1999 Volpe Report concluded that reflective materials enhanced motorists' ability to detect the presence of a train in a highway-rail grade crossing and could therefore prevent collisions involving highway vehicles. Unlike earlier studies which utilized previous generations of reflective material, the 1999 Volpe Report concluded that the durability and adhesive properties of the new microprismatic retroreflective material could provide adequate luminance intensity levels which can be sustained