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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: January 13, 1987

In reply refer to: R-86-49 through -57

Honorable Ray A. Barnhart
Administrator
Federal Highway Administration
Washington, D. C. 20590

The National Transportation Safety Board has had a longstanding objective to improve safety at railroad/highway grade crossings. In calendar year 1985, the Safety Board investigated 75 accidents involving passenger/commuter trains to determine safety issues that could be successfully addressed by Federal agencies, States, and other organizations responsible for the public's safety. As a result of a safety study 1/ based on these 75 accidents, the Safety Board remains concerned that the public (motor vehicle occupants and passengers on trains) and railroad employees are placed in life-threatening situations daily at grade crossing locations, where the Safety Board believes safety improvements can be accomplished.

From 1981 through 1985, the number of collisions between trains and motor vehicles at grade crossings averaged 7,350 annually. These collisions produce the largest single group of fatalities and injuries from railroad operations — an average of 580 fatalities and 2,700 injuries a year. In 1985, the Safety Board undertook a special accident investigation program to look at passenger/commuter train and motor vehicle collisions at grade crossings. Certain collisions were selected for this special investigation primarily because the passenger loads on these trains elevated the risk exposure to the traveling public at these locations.

The safety study addressed the following safety issues:

- Grade crossing characteristics, including roadway approach design, angle of intersection, multiple tracks, elevated surface profile, and masked flashing lights and sunglare.
- Obstructions, both movable and immovable, limiting the driver's sight distance.

1/ For more detailed information, read Safety Study Report—"Passenger/Commuter Trains and Motor Vehicle Collisions at Grade Crossings (1985)" (NTSB/SS-86/04).

- o Ineffectiveness of a train's audible warning system.
- o Routing of vehicles, particularly heavy trucks, away from grade crossings that do not have active warning devices to crossings that do have such devices or to crossings with better crossing characteristics.
- o Inadequacy of warning time for multiple-trailer units.
- o Signal controls unprotected from damage by vehicular traffic.
- o Additional warning signs at identified hazardous crossings awaiting the installation of active warning device(s).

The Safety Board is particularly concerned about grade crossings with multiple tracks with no active warning devices to alert motor vehicle drivers of the approach of a high speed passenger train. The use of crossbucks is not adequate at these crossings. Few drivers can accurately assess the closing rate of a high speed passenger train or the distance it takes such a train to stop. Indeed, recent Federal Railroad Administration (FRA) data 2/ indicated that the average motor vehicle driver would perceive a train traveling directly toward the driver at 60 mph as moving at 12 mph. If the multiple track crossing is lengthy, some motor vehicle drivers will disregard passive warning signs and venture onto the crossing, thinking they can tell which track the train is on and stop before reaching that track.

The crossbuck sign, the primary warning device found at the 122,959 locations throughout the nation, is inadequate to warn drivers of the dangers they face at multiple track intersections. The Safety Board addressed this concern as early as 1976 in Safety Recommendations R-76-13 and -14 to the U.S. Department of Transportation (DOT) suggesting that (1) the DOT require flashing lights and gates as minimum protection at all grade crossings used by commuter trains and (2) that DOT contemplate a grade separation program. Issued 10 years ago, these recommendations had not been fully addressed by the DOT. The DOT's most recent response prepared by the FRA on August 5, 1986, requests that these recommendations be closed based on its efforts in conjunction with the Federal Highway Administration (FHWA) to provide to States an automated procedure for developing an initial listing of grade crossing projects in order of their potential benefit-to-cost ratio.

The Safety Board is cognizant that in certain sections of the country many grade crossings with low traffic activity do not meet "potential benefit-to-cost ratio" criteria. However, the risk of a passenger train and motor vehicle collision poses a constant and serious condition that can cost many lives. The Safety Board believes that grade separations or crossing closures are the most advantageous ways to eliminate grade crossing collisions. However, the high cost of separations often precludes action. Crossing closure, on the other hand, can be cost effective in some situations; however, the public quite often reacts adversely to this suggestion. Recognizing that neither of these two means are extensively used, the Safety Board, therefore, believes that a minimum standard must be set for all locations where high speed passenger/commuter train operations involve a larger number of individuals and intersect with motor vehicle operations. This was the Safety Board's intent in Safety Recommendations R-76-13 and -14.

2/ Mr. Phil Oleksyzk, Deputy Associate Administrator for Safety, FRA, "Train Speed Issues," presented at the Fourth National Operation Lifesaver Symposium, St. Louis, Missouri, June 18, 1986.

However, since the States are now responsible for grade crossing improvements at these locations, the Safety Board believes that the States should determine the priorities for grade crossing safety improvements and should take actions to ensure that public grade crossings used by passenger or commuter trains are given high priority for installation of active warning devices. Consequently, the Safety Board's Safety Recommendations R-76-13 and -14 to the DOT have been placed in a "Closed—Reconsidered" status. A new recommendation to those States that have passenger and commuter operations is being issued.

Another extremely dangerous condition at multiple track locations is the activation of active warning devices (flashing lights and/or gates) that halt motor vehicle traffic although no train appears. This situation most commonly occurs where railroad yard switching operations some distance from the grade crossing activate the warning devices. If railroad management and State highway departments allow such conditions to continue unabated, motor vehicle drivers become conditioned to believe that warning devices at grade crossings do not necessarily indicate that a train is approaching. This leads motorists to disobey the signals, thus establishing a pattern for collisions between trains and motor vehicles.

One promising approach to this problem has been implemented by the State of Texas, whose legislature directed the Texas Department of Public Safety (DPS) to establish a toll-free telephone service to receive calls reporting grade crossing signal malfunctions. The State Department of Highways and Public Transportation (SDHPT) was required to attach a sign with the toll-free telephone number and DOT-AAR grade crossing inventory number to each train-activated warning device on the State-maintained highway and road system. Members of the public can report problems at these grade crossings to the DPS; the DPS then contacts the appropriate railroad to correct the reported condition. The railroads, according to those persons involved in implementing this system, have responded favorably to the system and have in a timely manner dispatched signal maintainers and others to correct the deficiencies reported.

So far, 3,400 such signs have been installed at 1,700 crossings in Texas. The system has generated 5,100 calls from the public in a 28-month period, or approximately 6 to 7 calls per day. The major malfunctions reported were "Signal Operating—No Train Visible" (84 percent), "Signal Not Operating Properly" (4.3 percent), "Vandalism" (2.7 percent), and "Other" (9 percent). Problems reported in the "Other" category included a truck stalled on the tracks, brush obstructing the view of the crossing, and a train blocking the intersection.

Legislation has been introduced in New York State that proposes a program comparable to the Texas program. However, New York's proposed legislation places more responsibility on the railroads operating in the State, requiring the carriers to:

- Conduct regularly scheduled inspections of safety equipment (grade crossing).
- Post at rail crossings the penalties for motorists who ignore warning lights or crossing gates.
- File biannual reports to the State Department of Transportation outlining details of corrective action taken in response to reported incidents of malfunctioning equipment.
- Keep records of equipment inspections and repairs on file for inspection by the Department.

The Safety Board believes that the Texas and proposed New York programs warrant serious consideration by the FRA and the FHWA as a partial solution to the problem of active warning devices operating in the absence of a train near the crossing. The FRA is currently evaluating the Texas system. The FRA and FHWA should complete evaluation of the Texas system and the proposed New York system and develop an appropriate strategy to implement the concept in all States.

While multiple tracks and warning devices constitute some of the problems encountered in grade crossing accidents, the Safety Board found visibility (sight distance) to be a continuing and troublesome concern. Indeed, in 24 of the accidents investigated by the Safety Board, visibility was cited as a cause.

The driver's view of the train's approach to the grade crossing was obscured in most cases by vegetation (16 cases), followed by fixed structures (9 cases), standing/stored railroad cars (4 cases), curvature of track (4 cases), and terrain (3 cases). In some cases, the driver's view was obscured by more than one of these conditions.

Sight obstructions render many grade crossings unsafe for motorists. Even at crossings with active warning systems, sight obstructions increase the opportunity for collisions; at crossings with no warning systems or only passive systems, such obstructions are especially dangerous. However, no Federal standards prohibit these obstructions, require their removal, or require additional strongly worded warning signs for motorists approaching a sight-obstructed crossing. In 1978, the FHWA did publish some guidance to State, municipal, and railroad authorities concerning recommended sight distances at grade crossings in the Railroad-Highway Grade Crossing Handbook. However, this guidance is not mandatory and is frequently and widely ignored.

Federal standards should be promulgated for the two main categories of sight obstructions found at grade crossings: movable (vegetation, standing railroad cars) and non-movable (buildings or the terrain itself). For movable obstructions such as vegetation, the standards should require the railroad to maintain, at each grade crossing, that portion of the "sight triangle" that is within the railroad right-of-way. In most cases, this would entail periodically removing vegetation or keeping it to some defined maximum height within "the sight triangle." The State should be responsible for maintaining the portion of the "sight triangle" not on railroad right-of-way. For such movable obstructions as standing rail cars, Federal standards should simply prohibit them within the appropriate sight triangle.

Non-movable obstructions obviously require a different approach. Since they cannot be moved, it is important that approaching motorists receive adequate warning that they may be unable to see an approaching train in time to stop and that special caution is therefore required. Such warning is particularly necessary at crossings used by high speed trains. Roadway advance signing, with messages such as "HAZARD/OBSTRUCTED VIEW/HIGH SPEED TRAIN" or "DANGEROUS TRAIN CROSSING/OBSTRUCTED VIEW" should be placed at all crossings with non-movable obstructions within the minimum "sight triangle." First priority should be given to signing crossings with high speed trains.

The Safety Board believes that the FHWA should lead in developing standards that require States to maintain sight distances at grade crossings. Additionally, the FHWA should develop and require the use of warning signs that alert motorists to crossings with limited sight distance if obstructions cannot be removed.

Another factor in grade crossing accidents is the ineffectiveness of trains' audible warning systems, which in 27 cases was cited as a factor in the collision between motor vehicles and passenger/commuter trains.

In the early days of automobile and train transportation, the steam whistle from a slow moving, approaching train easily alerted the slow moving motorist approaching a crossing; often, the motor vehicle was an open or cloth-covered vehicle. In fact, the whistle may have been the primary alerting device at crossings with no active warning or watchman, and only limited bells and wigwags. Today, the train's warning horn has become an ineffective warning device. Trains move at speeds of up to 79 mph, and motor vehicles approach crossings at speeds up to 55 mph. With the windows up, air conditioning or heater fan on, wipers on, and/or radio equipment blaring, the motor vehicle operator does not hear the train until it is too late to take evasive action, as seen in repeated accident investigations. The Safety Board's audibility tests have repeatedly indicated that, in a truck, the engine noise alone will usually mask an Amtrak or freight train horn until 1 or 2 seconds before impact, if the motor vehicle's windows are up. To hear a train's horn, a truckdriver must stop, let the engine idle, turn off fans, wipers, and radios, and roll the window down. At passive crossings, truckdrivers must be especially cautious. At active crossings, sun glare or other obstructions to the active devices can further reduce their effectiveness, thus making the train's horn a more critical part of the overall warning system than it can adequately fulfill.

One of the first Safety Board accident investigations to include audibility tests of train horns was in 1967. 3/ The accident occurred on October 2, 1967, when a schoolbus carrying 13 children was driven across a highway grade crossing with passive warning devices and was struck by a train. Four of the children on the bus were killed and the other nine injured. The Board's report of this accident stated that:

> The data collected and [their] analysis strongly support the proposition that the bus driver, with the bus door closed, could hear the train whistle for. . .approximately 6 seconds or 510 feet prior to the locomotive's arrival at the crossing. With the front door of the bus open, the whistle could be heard for. . .approximately 13.5 seconds or 1,150 feet away. . . .The analysis of horn and other sounds reported in this report establishes that the train was too far away for the driver to hear the horn while the bus was stopped even if the door was open, and that once the door was closed and the bus was moving toward the tracks in low gear, the horn could not be heard inside the bus until it was too late for the bus to stop short of the crossing.

In response to the Board's safety recommendation from this accident (H-68-8), 4/ the FRA sponsored an audibility study 5/ that described adequate audible warnings as a function of three factors:

3/ For further information, see Accident Report—"Public School Bus-Union Pacific Railroad Company Freight Train Accident, Waterloo, Nebraska," issued September 2, 1968 (NTSB/RHR-1).

4/ The Safety Board's Safety Recommendation (H-68-008) reads as follows: "FHWA and FRA study the questionable audibility of external sound signals within motor vehicles and work toward creating a unified system of warnings and reliable reception, to be made effective through Federal regulations or State laws." The status of this recommendation is "Closed—Acceptable Action."

5/ John P. Aurelius and Norman Korolow, "The Visibility and Audibility of Trains Approaching Rail-Highway Grade Crossings," FRA-RP-71-2, May 1971.

- Sound level at the vehicle.--For a motorist in a vehicle moving less than 35 mph, a sound level of at least 101 decibels is needed; for those moving at 36 to 50 mph, the required level is 105 decibels; for those at 51 to 65 mph, 109 decibels.

- Required distance.--The required decibel level must be perceived by the motorist before he or she has passed the threshold of the stopping distance needed for the speed at which he or she is traveling.

- Sound attenuation.--Power in a sound dissipates as it moves away from its source (as light does); the power varies from the level at the source by the inverse square of the distance (between 1 and 4 feet from the source, the sound has spread out over an area 16 times larger than the area affected at the source, and the power is 1/16 as great).

Amtrak's Nathan K5LA air horns (five forward-facing horns) produce 113 to 114 decibels of sound at 100 feet directly in front of the train. However, if the train were moving at 50 mph, it would traverse approximately 100 feet in little more than one second--hardly sufficient warning. When measured at a 45° angle from head-on, the sound was 112.5 decibels at 100 feet, and from a 90° angle and 100 feet, it was 109.5 decibels--an even lower level of warning effectiveness.

Locomotive train horns (freight or passenger) are required to meet Federal standards of only "96 [decibels] at 100 feet forward of the locomotive in its direction of travel. . . ." The Federal standard also permits a measurement variation of 4 decibels. 6/ The Safety Board believes that the Federal standard should at least meet the decibel warning levels produced by the Amtrak train air horns. This would give motorists who cautiously approach railroad/highway grade crossings a much improved safety warning from the train's audible warning systems. The present FRA standard is inadequate.

The 1971 FRA study concluded that "railroad horns [as designed now] cannot reliably warn motorists when either the train or motor vehicle is going [faster than] 50 mph." As the author put it:

> To "warn" a motorist, the sound must penetrate into his [or her] vehicle and override ambient noise. . ., while the vehicle is far enough away from the crossing to still be able to stop. It is not suggested that horns are seldom heard by motorists, but rather that they fail to reach some motorists and are thus questionable as [a] primary warning device.

The authors recommended the following:

- Use a high output horn, such as the five-chime type, because of its alerting qualities, its ability to override masking sounds, and its lesser nuisance value.

- Mount horn high and on the front to reduce the nuisance to the crew and improve performance.

6/ 49 CFR 229.129, "Audible Warning Devices," Railroad Locomotive Safety Standards.

- o Mount a horn on each end of bi-directional locomotives.

- o Lower the highway speed limits at the approaches to crossings where audible warnings must have a primary role (poor visibility, no active control devices).

The Safety Board believes that the FHWA should make every effort to inform truckdrivers that the audible warning systems currently used by passenger trains and high speed freight trains cannot be relied on to warn of a train's approach and that drivers should roll down their windows, turn off radios and CB units, and listen carefully for a train before proceeding across any grade crossing location with passive warning devices.

In addition to the train's horns, flashing lights warn motorists of an approaching train at many crossings. In 24 (32.0 percent) of the 75 collisions investigated for this study, a red flashing light was involved. Apparently, these devices do not clearly convey an effective "STOP" message to many motorists. To some extent, this may be the result of motorists experiencing a "false positive" signal (warning device on, but no train appearing), so that they learn to disregard the signal. Perhaps, for many motorists a flashing red light is not as clear and strong a "STOP" signal as is a steady red light. (Some motorists of course, may attempt to "beat" the train, regardless of the warning signal used.) While the Uniform Vehicle Code (UVC) clearly states that "No person shall drive any vehicle through, around or under any crossing gate or barrier at a railroad crossing while such gate or barrier is closed or is being opened or closed . . .," there is no such guidance or prohibition for red flashing lights. Indeed, the red flashing light only means stop and proceed when safe to do so. There is no language that prohibits a person from driving through the flashing red signal. The UVC is very clear that at a steady red indication a motorist ". . . shall remain standing until an indication to proceed is shown . . . ." This is basically the same intent as a gate.

The Safety Board believes that the safety community should seriously consider highway traffic control signals at grade crossings. Motorists are more familiar with, and conditioned to obey, highway traffic control signals; if these fail to function properly, motorists may be more likely to report the failure, so that incorrect warning messages are not conveyed to motorists over a long period. The use of the flashing red light should be questioned if the intent is for a motorist to make an absolute stop at a grade crossing and wait for a train to pass. It would seem more appropriate to require a steady red indication so that motorists would remain standing until the signal indicated that they could proceed.

A number of accidents occur at grade crossings that State officials have previously identified as hazardous crossings based on a hazard index formula. These grade crossings are targeted for active warning devices(s) installation because the crossings are known to be hazardous based on, but not limited to, such factors as expected number of accidents, average traffic volume, average train volume, angle of crossing factor, protection factor, type and speed of train factor, and others.

In a number of cases investigated by the Safety Board, the crossings had been placed on a State list of priority crossings or had otherwise been identified as a location for active warning device installation or for upgrading to a higher active warning device level (for example, from flashing lights to gates and flashing lights.) The installation either had not occurred or was accelerated only after the fatal accident at the crossing location.

The Safety Board believes that grade crossings clearly identified by the States as hazardous and crossings that have been placed on an official list for installation of upgraded warning device need to be provided with additional interim warning signs indicating the hazardous crossing location. The interim warning sign should indicate that the crossing is considered to be a dangerous location and that upgraded warning devices will be placed at the crossing location as soon as possible. Once the upgraded warning devices are in place, the interim warning signs could be removed.

The Safety Board, as a result of this study, believes that the FHWA must review the length of grade crossing warning times for "double bottom" or other multiple trailing units and act to correct conditions that place passenger trains and long, heavy trucks on a collision course. The FHWA has issued "Truck Size and Weight National Network Guidelines" under 23 CFR Part 658 that designate the U.S. interstate, primary, and arterial road network for use by multiple trailing units. Grade crossing safety considerations, such as the adequacy of clearance time, was not considered a specific factor in the final guidelines. The Safety Board believes that the adequacy of clearance time for multiple trailing units is a serious safety problem and believes that the FHWA should review those sections of the designated road network that include grade crossings and determine if the clearance times of grade crossings in this network have been determined safe for such units. As one interim measure, the FHWA should issue an "On Guard" Bulletin, warning companies and drivers of multiple trailing units that grade crossings with active warning companies and devices may not be safely traversed if the warning time before the train's approach is no more than 20 to 25 seconds. Companies and truck drivers of these units should take steps to verify with the railroads the crossing clearance times for grade crossings on routes they travel. This action would at least alert truckdrivers to the potential hazard of inadequate warning clearance times at grade crossings. The 20-second minimum found in the MUTCD (Section 8C-5), which railroads and States have adopted as a voluntary standard, should now be carefully reviewed in light of the proliferation of longer heavy truck units.

A recent study completed for the FHWA, entitled "Consequences of Mandatory Stops at Railroad-Highway Crossings," Report No. FHWA/RD-86/014, reports that "the increased use of double and triple bottom truck trailers results in the minimum MUTCD advance warning of 20 seconds being insufficient at many railroad grade crossings."

The Safety Board's study also addressed railroad signal control boxes unprotected from damage by errant motor vehicles, particularly if the system is not integrated with the highway traffic light system for roadways adjacent to or leading across the crossing.

The Safety Board believes that signal control boxes that govern active warning systems must not remain unprotected from highway traffic incursions at major thoroughfares. The FHWA, the FRA, and State safety agencies need to review the damage protection provided for roadside signal control boxes. A number of innovative barriers that are available and in use by State highway departments could be used to protect grade crossing signal control boxes at such locations. If such protection, which does not increase the risk to motorists, cannot be provided because interpretation of local, county, or State laws and regulations is inconsistent, then uniform Federal standards will be necessary.

Therefore, as a result of its safety study of collisions at railroad/highway grade crossings, the National Transportation Safety Board recommends that the Federal Highway Administration:

Require State highway departments to maintain sight distances at grade crossings by ensuring the roadside is free of obstructing vegetation or other sight obstructions. (Class II, Priority Action) (R-86-49)

Develop and require the use of advance warning signs that clearly inform motor vehicle drivers of particular dangers at grade crossings, including the warning of limited sight distance and high hump profile surface. (Class II, Priority Action) (R-86-50)

Develop and require installation of a specific advance warning sign for grade crossing locations identified by States as hazardous at locations awaiting upgrade to an active warning device. (Class II, Priority Action) (R-86-51)

Issue an "ON GUARD" bulletin to all motor carriers, advising that the audible warning systems currently used by passenger trains and high speed freight trains cannot be relied on to warn of a train's approach and that it is imperative that drivers approach any grade crossing with passive warning devices as an extremely hazardous location. (Class II, Priority Action) (R-86-52)

Issue an "ON GUARD" bulletin to all motor carriers, encouraging drivers of "double bottom" trucks or with three trailing units to use routes with grade separations whenever feasible. (Class II, Priority Action) (R-86-53)

In the truck size and weight national network guidelines, include the adequacy of clearance times for multiple truck units at grade crossings. Review those sections of the designated U.S. primary and arterial road network that include railroad/highway grade crossings and determine if the warning device clearance times of crossings in this network have been determined safe for such units. (Class II, Priority Action) (R-86-54)

In conjunction with the Federal Railroad Administration, assist in the development and requirements for a system in each State similar in concept to the State of Texas public toll-free system to report active warning devices that are operating when no train is nearing the crossing, or other problems or malfunctions. (Class II, Priority Action) (R-86-55)

In conjunction with the Federal Railroad Administration, require roadside barrier protection of grade crossing signal control systems located adjacent to the roadway. (Class II, Priority Action) (R-86-56)

In conjunction with the Federal Railroad Administration, study, report, and undertake further demonstrations on the feasibility of adopting highway traffic signals as primary warning devices at grade crossings. (Class II, Priority Action) (R-86-57)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and LAUBER and NALL, Members, concurred in these recommendations.

By: Jim Burnett
Chairman