Log H-530C

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 5, 1989

In reply to refer to: H-89-4 through -6

Honorable Diane K. Steed
Administrator
National Highway Traffic Safety
Administration
Washington, D.C. 20590

About 10:55 p.m. eastern daylight time on May 14, 1988, a pickup truck traveling northbound in the southbound lanes of Interstate 71 struck head-on a church activity bus traveling southbound in the left lane of the highway near Carrollton, Kentucky. As the pickup truck rotated during impact, it struck a passenger car traveling southbound in the right lane near the church bus. The church bus fuel tank was punctured during the collision sequence, and a fire ensued, engulfing the entire bus. The busdriver and 26 bus passengers were fatally injured. Thirty-four bus passengers sustained minor to critical injuries, and six bus passengers were not injured. The pickup truck driver sustained serious injuries, but neither occupant of the passenger car was injured.[1]

Test results on a blood specimen taken from the pickup driver about 1 1/2 hours after the accident indicated a blood alcohol concentration (BAC) of 0.26 percent, which is more than 2 1/2 times the legal limit at which a person is generally presumed intoxicated. With such a high BAC, the pickup driver would have been extremely intoxicated. Considering the average rate of metabolism for ethyl alcohol (0.015 percent per hour) and assuming the pickup driver was in the elimination phase, his BAC would have been 0.28 percent at the time of the accident. However, based on the driver's drinking history, a rate of elimination of 0.015 percent per hour is a conservative estimate of his rate of alcohol metabolism, and his BAC at the time of the collision may have been higher than 0.28 percent.

A witness who had been driving southbound on I-71 9 miles north of the accident site said the pickup truck was being operated erratically. He also said that he passed the pickup truck and a tractor-semitrailer in an effort to keep away from them in case of an accident. The witness had observed the pickup truck cross the median strip north of the accident site, had later observed the pickup truck going northbound in the southbound fast lane, and

[1] For more detailed information, read Highway Accident Report--"Pickup Truck/Church Activity Bus Head-on Collision and Fire near Carrollton, Kentucky, May 14, 1988" (NTSB/HAR-89/01)

had tried to alert the pickup driver by blowing his horn and flashing his lights. Two other witnesses who saw the collision said that before the accident the pickup truck was driving northbound in the southbound lanes.

Based on the results of controlled studies of the effects of alcohol on human behavior and performance, the Safety Board believes that the pickup driver's high alcohol level diminished his awareness of his surroundings, his abilities to recognize the extremely hazardous situation, and his ability to avoid the collision. Therefore, the Safety Board concludes that the physical impairment of the pickup driver, as a result of alcohol intoxication, caused the accident.

The poly(vinyl)chloride-covered and polyurethane padded seat cushions provided the source of fuel for the fire once it spread inside the bus. Hydrogen chloride is a toxic product that is produced when this material is burned. The surviving passengers described extremely difficult conditions on the bus, including thick, black smoke; hot seats and floor; and plastic dripping from the ceiling. Many complained of the limited visibility due to the thick black smoke and some lost consciousness because of the smoke/fumes.

Heat and toxic products accumulated first in the ceiling area of the bus. Assuming that a carboxyhemoglobin saturation of 50 percent is fatal, only 33 percent (9) of the deaths from the accident could be attributed to fatal carbon monoxide exposure alone. Thus, at least 66 percent of the victims must have died from other factors, such as heat and/or other toxic gases. Inhalation injuries are symptomatic of exposure to a strong irritant, such as hydrogen chloride which produces severe irritation and chemical acid burns when it contacts the moist mucous membranes of the eyes, nose, throat, and lungs. The corneal burns were most likely due to exposure to hydrogen chloride. The Safety Board concludes that the exposure to hydrogen chloride and black soot most likely contributed to the inhalation injuries of survivors as well as those fatally injured.

The Safety Board is aware that the National Institute of Standards and Technology (NIST) is currently developing acceptance criteria to limit the rate of fire growth in school buses. The study will be directed toward currently used and state-of-the-art material assemblies for school bus seats. The Board urges the NHTSA, when the study is completed, to incorporate the NIST recommendations concerning the new material acceptance criteria to reduce the rate of fire spread in all buses.

According to survivors, passengers crawled over seatbacks and on top of each other in an attempt to reach the rear exit door. Some survivors stated that the seats became so hot that the passengers were forced into the crowded aisle. By the time they did reach the exit door, which was blocked by other passengers trying to exit at the same time, many could not get out before being overcome by smoke.

The main problems during the evacuation were the insufficent number of exits and the rearmost bench seats which intruded into the opening at the rear exit. The opening at the rear exit provided about 14 square feet of exit area. However, the two full-length rear bench seats overlapped the rear exit opening by as much as 24 inches in width, leaving a space of only 15 inches wide at the top of the seats and 12 inches wide toward the bottom of the seats. Had the full length rear seats been replaced by smaller seats, the aisle between the last two bench seats would have been 36 inches wide allowing more passengers to exit the bus. Thus, the reduced exit opening resulted in the occupants being exposed for a prolonged time to the toxic environment and increased the severity of injuries.

Two survivors stated that they escaped through a window, and others stated that they tried without success to kick out the windows. Had the passengers been able to escape from more than just two windows, it is very likely that more passengers would have survived this accident.

Since 1969, the Safety Board has investigated four accidents[2] and issued five safety recommendations to the FHWA, the NHTSA, and the bus manufacturing industry urging them to provide for additional emergency exits to facilitate escape from the access to buses regardless of the vehicle's attitude following a collision or overturn. The four accident investigations involved one school bus and three charter buses. In each accident, the Safety Board concluded that the lack of adequate exits hampered emergency egress.

Federal Motor Vehicle Safety Standard (FMVSS) 217 requires a certain specified opening for emergency egress. Therefore, in poststandard buses, if the last row of seats is less than 1 foot forward of the rear exit door, one of the bench seats must either be shortened or completely removed. However, the standard does not require more than one emergency exit. Currently, FMVSS 217 provides for more emergency exit area for nonschool buses than the amount of area required for school buses. The minimum standard for school buses requires a set number of openings at a particular place in the bus. The minimum standard for nonschool buses requires an amount of exit area per passenger seating position with a set maximum amount of area at any given location, which forces the manufacturers to divide the exit area into different locations in the bus. (Thus, the provisions for nonschool buses in FMVSS 217, to some degree, govern the number and locations of emergency exits throughout the bus. NHTSA officials have been unable to explain to the Safety Board the reasons for the differences in the standards for school buses and nonschool buses.

Currently, the provisions for school buses in FMVSS 217 do not address the anthropometric population of bus occupants or the passenger seating capacity. In most instances, to increase the seating capacity in school buses, manufacturers either extend the body length or reduce the aisle width.

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[2] Highway Accident Report,--"Interstate Bus-Automobile Collision, Interstate Route 15, Baker, California, March 7, 1968" (unnumbered); "Tractor-Semitraler/Schoolbus Collision and Overturn, Rustburg, Virginia, March 8, 1977" (NTSB-HAR-78-01); "Chartered Interstate Bus Crash Interstate Route I-80S, Near Beaver Falls, Pennsylvania, December 26, 1968" (unnumbered); Greyhound Lines Bus Collision with Concrete Overpass Support Column on I-880, San Juan Overpass, Sacramento, California, November 3, 1973" (NTSB-HAR-74-5); Washington, D.C. June 9, 1975 (NTSB-HAR-74-5).

Both plans can adversely affect a bus passenger's ability to enter the aisleway and exit the bus.

Current guidelines established by the Minimum Standards Conference specify that the aisle in school buses be at least 12 inches at the floor and 15 inches at the top of the seatbacks. This guideline is applicable to all bus sizes. Thus, a 24- and a 90-passenger school bus can have the same aisle width and one emergency exit in the rear, and both would be in full compliance with the guidelines and the current egress requirements for FMVSS 217.

Interviews with the surviving passengers did not indicate that the aisleway impeded their egress. However, some passengers began climbing on the seats almost immediately to get to the rear of the bus, and when they reached the emergency door, not only was the aisle full, but the seats on either side of the doorway were crowded with people trying to get out. Seven to eight people crowded into the doorway at one time. Many passengers would make some progress toward the exit but were then pushed down into a seat or stepped on. The Safety Board concludes that had the aisle been wider, more passengers could have stood in the aisle (rather than climbing on the seats) and exited the bus more rapidly. The Board believes that the aisle width of buses should be commensurate with bus seating capacity to accommodate the maximum number and size of passengers. Further, proposed changes to FMVSS 217 to address this issue should also be incorporated in the existing provisions for nonschool buses. Thus, the Safety Board believes that the NHTSA should revise FMVSS 217 to ensure that bus exit requirements are based on bus capacity and be no lower than those for nonschool buses.

The fuel tank of the accident school bus complied with FMVSS 301, Fuel System Integrity. At the time the accident school bus was purchased, Ford offered the fuel tank guard as an option, and holes for a fuel tank guard had been drilled in the bus chassis. However, the Kentucky Department of Education did not order school buses with the optional fuel tank guards.

Due to the complex crash kinematics in this accident, it is difficult to predict if and how the results of the accident may have differed if the bus had been equipped with a fuel tank guard. The guard may have withstood the impact and prevented the fuel tank from being pushed rearward, or it may have permitted the fuel tank to be pushed rearward somewhat. It is unlikely that a tank with a guard would have moved relative to the chassis precisely as did the tank (without a guard) in this accident.

A tank guard would have caused the kinematics of the tank relative to the chassis to have differed from this accident; therefore, it is not possible to state, conclusively, where the tank would have been struck. The Safety Board's examination of a poststandard bus equipped with a fuel tank guard revealed that a Ford fuel tank guard would have covered the area punctured on the accident fuel tanks. Portions of the dented and scraped areas of the accident fuel tank, however, would not have been covered by a Ford fuel tank guard. Although fuel tank guards are not designed to protect fuel tanks from punctures, had the tank been equipped with a guard and in the unlikely case the fuel tank had been struck in the same location as in this accident, it is possible that a guard could have prevented puncture of the fuel tank. It is also possible that the tank may have been struck with sufficient energy that a guard could not have prevented the puncture.

In a slightly different accident, an object could puncture a fuel tank equipped with a Ford fuel tank guard in an unprotected location. However, because a fuel tank guard may cover as much as half of the front, rear, and sides of a fuel tank and is made of heavy gauge steel, the fuel tank guard provides protection not afforded to tanks without the guards. Certainly, fuel tank guards offer greater protection against penetration (and spillage) than fuel tanks not equipped with guards (such as was the case in this accident).

Although the national statistics suggest that the incidence of fire in school buses is relatively rare, the Safety Board is concerned that the fires could spread to the occupant spaces of school buses and cause injuries and deaths. The Board is not aware of any other accident in which fatalities resulted from a fuel tank rupture on a school bus. However, based on the Board's investigation of 10 school bus and school van accidents that involved fires (including the most recent school bus fuel-fed fires at Carrollton, Kentucky, and Kansas City, Missouri), there is a significant potential for fire to spread inside the passenger compartment.

Current Federal fuel system integrity requirements provide adequate protection for large school buses in most accidents. However, additional improvements to the fuel system are needed to prevent fires in severe accidents such as those at Carrollton and Kansas. For severe accidents in which the crash forces are transferred to the chassis structural members, but damage to the fuel tank and tank guard is minimal, improvements are needed to prevent leakage of fuel from separated fuel lines. Possibly, the use of frangible shutoff valves in critical locations could prevent the spillage of all but a minor amount of fuel in the accidents in which the fuel lines have been separated from the tank or engine during collisions.

In severe accidents in which sufficient crash forces are absorbed by the fuel tank and the tank guard which breach the tank, improvements are needed to preclude or minimize the amount of fuel leakage and, if fire erupts, to delay its spread into the passenger compartment. Research and testing is needed to evaluate the merits of relocating the fuel tank possibly between the frame rails or further rearward of the entrance door area, or of providing additional structure or shields in front of the existing tank to better protect it from crash forces that occur in severe frontal collisions, and to deflect heat buildup beneath the tank in the event of a fire. Because of the significant potential for fire in school buses, particularly in severe frontal crash situations, the Safety Board believes that National Highway Traffic Safety Administration (NHTSA) needs to strengthen FMVSS 301 to provide additional protection from fire.

Therefore, the National Transportation Safety Board recommends that the National Highway Traffic Safety Administration:

Incorporate in Federal Motor Vehicle Safety Standard 302 the recommendations of the National Institute of Standards and Technology concerning the new material acceptance criteria to reduce the rate of fire spread in all buses. (Class II, Priority Action) (H-89-4)

Revise Federal Motor Vehicle Safety Standard 217 to require that school bus egress be based on vehicle occupant capacity and be no lower than those currently required for nonschool buses. (Class II, Priority Action) (H-89-5)

Revise Federal Motor Vehicle Safety Standard 301 to provide additional protection for school buses in severe crash situations based on an evaluation of the merits of relocating fuel tanks, providing additional structure to protect fuel system components, and using frangible valves in critical locations. (Class II, Priority Action) (H-89-6)

Also, the Safety Board issued Safety Recommendations H-89-1 to the 50 States and the District of Columbia; H-89-2 to the 49 States, except Kentucky, and the District of Columbia; H-89-3 to various church associations and other special activity groups; H-89-7 to the Federal Highway Administration; and H-89-8 through -14 to the State of Kentucky.

KOLSTAD, Acting Chairman, and BURNETT, LAUBER, NALL, and DICKINSON, Members, concurred in these recommendations.

James L. Kolstad

By: James L. Kolstad
Acting Chairman