R-638

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: December 8, 1992

In reply refer to: R-92-10 through -13

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In 1990, the Safety Board investigated three major accidents involving collisions and derailments of locomotives that resulted in diesel fuel fires from ruptured locomotive fuel tanks.[1] Six crewmembers were fatally injured in the first two of these accidents, five of whom died as a result of extensive thermal burns and asphyxiation by smoke inhalation.[2] The investigation of the third major accident,[3] involving a passenger train in a tunnel, revealed that diesel fuel spilled from a ruptured locomotive fuel tank. The fuel ignited and the resulting smoke and fumes increased the level of hazard in the postcrash phase of the accident, hindering emergency response and rescue activity. Seven rescue personnel were treated for smoke inhalation and many passengers complained of smoke conditions.

These accidents heightened the Safety Board's concern about the potential for diesel fuel fires in railroad accidents to fatally injure trapped crewmembers, consume cargo, contribute to hazardous materials fires in the train, and endanger nonrailroad property near the accident site. Because of this heightened concern, the Safety Board initiated a study of this issue.

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[1] (a) National Transportation Safety Board. 1991. Atchison, Topeka and Santa Fe Railway Company (ATSF) freight trains ATSF 818 and ATSF 891 on the ATSF Railway, Corona, California, November 7, 1990. Railroad Accident Report NTSB/RAR-91/03. Washington, DC. (b) National Transportation Safety Board. 1991. Collision and derailment of Norfolk Southern train 188 with Norfolk Southern train G-38 at Sugar Valley, Georgia, August 9, 1990. Railroad Accident Report NTSB/RAR-91/02. Washington, DC.

[2] The other fatally injured crewmember also suffered extensive thermal burns, but the cause of death was attributed to severe head trauma.

[3] National Transportation Safety Board. 1992. Derailment and collision of Amtrak passenger train 66 with Massachusetts Bay Transit Authority commuter train 906 at Back Bay Station, Boston, Massachusetts, December 12, 1990. Railroad Accident Report NTSB/RAR-92/01. Washington, DC.

As part of the study, the Board reviewed data from its investigations of 29 railroad accidents involving locomotive derailments that occurred in 1991. For most of the accidents, the investigators were able to obtain basic information on fuel tank damage and fuel spill from a review of photographs and other documentation obtained during the course of the investigations. The Safety Board recognizes that its data are limited and biased toward the more severe accidents.

Although the Board's data are limited and biased toward the more severe accidents (accidents that tend to result in injuries or fatalities), these data create concern about postcrash fires in the more severe derailments. Diesel fuel spills occurred from 47 (56 percent) of the 83 locomotives that derailed in the 29 locomotive derailment accidents investigated; further, fuel ignition occurred on 23 (28 percent) of the 83 locomotives that derailed.

The Board's selective investigation of the severe locomotive derailment accidents and the limited data available on locomotive fuel tank spills and fires precluded a comprehensive determination of the failure modes of locomotive fuel tanks. The investigations do demonstrate, however, that even in the low speed derailments, rail can dent and puncture the tank. The investigations also show that locomotive components and the track structure not only can dent and puncture, but they can crush the tank during the more severe derailments and head-on collisions, particulary if a locomotive turns over or one locomotive overrides another. Further, although the accidents investigated by the Board in 1991 in which there were fuel tank fires represent a small percent of the Federal Railroad Administration (FRA) reportable accidents involving locomotive derailments for that year, these accidents include 100 percent of the onboard crewmember fatalities. Thus, fuel tank damage, fuel spills, and fuel fires are a safety issue in the more severe locomotive derailment accidents.

It has been argued that fuel tanks cannot reasonably be designed for and placed on locomotives in a manner to reduce or eliminate ruptures in the more severe accidents. However, the Safety Board is not convinced that this is so. More importantly, it is clear that current fuel tanks have not been so designed nor has adequate research been performed to determine if improvements sufficient for fuel tanks to survive such accidents are possible.

The proximity of the bottom of the locomotive fuel tank to the top of the rail makes it highly susceptible to damage in the event of a derailment. Although the FRA only requires that no part or appliance of a locomotive (except the wheels, nonmetallic sand pipe extension tips, and trip cock arms) may be less than 2 1/2 inches above the top of the rail, information from the manufacturers indicates that fuel tanks are installed such that the bottom of the fuel tank is normally about 6 to 6 1/2 inches above the rail. However, even at that height, if the locomotive wheels come off the rails, fuel tank contact with the rails is likely to occur, as the Board's accident investigations illustrate. The current location of locomotive fuel tanks

extending to each side of the locomotive and underneath the locomotive frame also makes them vulnerable in side collisions and during overrides.

Amtrak's efforts to raise the fuel tank to a height of 29 inches above the rail and to compartmentalize the tank to minimize fuel loss in the event of tank damage appear to be improvements over the current design and location. In a low-speed derailment, tank damage would probably be minimal, if not eliminated. The Board recognizes that raising the location of fuel tanks above their current position and the possible concomitant need to raise other equipment could result in an increase in the center of gravity of the locomotive. Such an increase may have some effect on the maximum speed at which a locomotive could safely negotiate a curve. Clearly, center of gravity needs to be taken into consideration if the solution to improving fuel tank performance includes relocation of the fuel tank. Implementation of any strategy or concept to mitigate fuel tank breaches should be carefully evaulated and tested, through either simulation or crash testing, to assure that potential changes do not introduce new safety hazards--in particular, new breach mechanisms--and to determine the applicability of the concept or strategy to the industry. However, the Safety Board is not aware of any plans to test the Amtrak locomotive fuel tank to determine how the tank will perform in an accident environment.

Of particular concern to the Safety Board is that fuel tank design specifications do not appear to be adequately based on safety factors. Tank capacity was increased to enable railroads to travel greater distances without stopping to refuel and to bypass locations where the cost of diesel fuel was high. Although public concern about the harmful effects of releases of hazardous materials on the environment has been heightened in the last couple of years, the cost associated with cleaning up these spills appears to have been the driving force in one railroad's request to the manufacturer that the thickness of metal used on the end plates and side walls of the fuel tank be increased. Although the increased wall thickness should prevent some, if not many, of the breaches that would normally occur with the thinner metal, there have been no tests conducted to determine how the newly designed fuel tank would perform in an accident environment and what benefits would accrue.

The lack of any substantive change to the locomotive fuel tank over the years indicates that little effort has been made in the past to determine if the integrity of the fuel tank can be improved or if fuel containment could be improved. Although the Safety Board acknowledges that changes to the fuel tank design have recently been explored by the railroad industry, the Board found no evidence that the industry has performed systematic engineering analyses to determine the feasibility of providing better crash protection for the fuel tank systems. The Safety Board believes that the FRA, in conjunction with the Association of American Railroads (AAR) and the two major locomotive manufacturers--General Electric and the Electro-Motive Division of General Motors--should conduct research to determine if the locomotive fuel tank can be improved to withstand the forces encountered in the more severe locomotive derailment accidents or if fuel containment can be improved to reduce the rate of fuel leakage and fuel ignition. The research should include crash or simulated testing and evaluation of recent and

proposed design modifications to the locomotive fuel tank, including increasing the structural strength of end and side wall plates, raising the tank higher above the rail, and using internal tank bladders and foam inserts. The FRA should establish, if warranted, minimum performance standards for the locomotive fuel tank based on the results of the research.

The Safety Board is aware that the industry is experimenting with the use of fuel tenders, alternative fuels, and other fuels in combination with diesel fuels. The increased use of alternative fuels could conceivably reduce the incidence of diesel fuel fires or introduce new hazards in the accident sequence. The Safety Board acknowledges and supports the industry's efforts to assess the safety implications of alternative fuels and fuel tenders in the accident environment. With stricter emission standards expected in the near future, the use of alternative fuels can be expected to increase. The Safety Board, in noting the FRA's monitoring of the industry's experiments with the use of fuel tenders and alternative fuels, urges the FRA, in conjunction with the AAR, to develop a formal methodology for reviewing the use of fuel tenders and alternative fuels for the railroad industry.

The Safety Board concluded in its report of the 1990 accident at Corona, California, that "neither research nor accident data exist about the effect of ruptured or leaking locomotive fuel tanks in railroad accidents in which postcrash fires occurred." The FRA does not record data on locomotive fuel tank breaches, diesel fuel spills, or diesel fuel fires. The Safety Board, therefore, recommended that the FRA take the following action:

R-91-40

To enhance current accident data collection and analysis, require the recording of data pertaining to postcrash fires involving locomotive fuel tank rupture and spillage, as well as types of locomotive units involved.

The safety recommendation was issued to the FRA on August 23, 1991. On January 8, 1992, the FRA responded to the recommendation, stating:

The FRA is currently reviewing and revising its accident/incident forms and reporting procedures. Information on the performance of locomotive fuel tanks and the types of locomotive will be included in the new reporting procedures. In the interim, we will instruct the railroads to include this information in the narrative portion of the report form. The information will then be included in our accident/incident data base and available for our joint use in accident analysis.

In a letter of April 1, 1992, the Safety Board acknowledged FRA's response and classified Safety Recommendation R-91-40 as "Open--Acceptable Response," pending a progress report on FRA's activity in this area. On May 18, 1992, Safety Board and FRA staff met to discuss several safety recommendations that were being held in an "open" status, including R-91-40. At the meeting, the FRA indicated that the review of report forms and

reporting procedures was continuing. A further meeting between FRA and Safety Board staff was to be scheduled to provide guidance in developing the data forms. On September 30, 1992, the FRA provided Safety Board staff draft copies of revisions to accident/incident data reporting forms that address fuel tank damage and fuel spills.

As previously noted, there has been little change to the design of fuel tanks over the years, with the exception of tank capacity. However, even when the tank size was increased, the effect of increasing the quantity of locomotive diesel fuel onboard was not analyzed to determine if new safety hazards would be introduced. The Safety Board is concerned that in the event of a breach and ignition, the duration of a fire may be prolonged and the severity increased. The Safety Board believes, therefore, that the FRA, in documenting fuel tank damage and breaches during onsite investigations, should also document fuel tank size and the duration and severity of fires. In reviewing Safety Recommendation R-91-40, the Safety Board believes that it may not have conveyed as succinctly as possible the information that should be collected onsite with respect to fuel tank damage, fuel spills, and fuel fires. Consequently, the Safety Board has placed Safety Recommendation R-91-40 in a "Closed--Acceptable Action/Superseded" status and has issued a new recommendation that more clearly outlines the data collection needed.

Therefore, as a result of the safety study, the National Transportation Safety Board recommends that the Federal Railroad Administration:

> Conduct, in conjunction with the Association of American Railroads, General Electric, and the Electro-Motive Division of General Motors, research to determine if the locomotive fuel tank can be improved to withstand forces encountered in the more severe locomotive derailment accidents or if fuel containment can be improved to reduce the rate of fuel leakage and fuel ignition. Consideration should be given to crash or simulated testing and evaluation of recent and proposed design modifications to the locomotive fuel tank, including increasing the structural strength of end and side wall plates, raising the tank higher above the rail, and using internal tank bladders and foam inserts. (Class II, Priority Action) (R-92-10)
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> Establish, if warranted, minimum performance standards for locomotive fuel tanks based on the research called for in recommendation R-92-10. (Class III, Longer Term Action) (R-92-11)
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> Instruct field personnel to obtain from accident investigations locomotive fuel tank size and, to the extent practicable, the duration and severity of locomotive fuel fires in conjunction with the agency's ongoing efforts to improve the recording of data pertaining to postcrash fires involving locomotive fuel tank rupture and spillage. (Class II, Priority Action) (R-92-12)

Develop, in conjunction with the Association of American Railroads, a formal methodology for reviewing the use of alternative fuels and fuel tenders in the railroad industry. (Class III, Longer Term Action) (R-92-13)

Also as a result of the safety study, the Safety Board issued safety recommendations to General Electric, the Electro-Motive Division of General Motors, and the Association of American Railroads.

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HART, and HAMMERSCHMIDT concurred in these recommendations.

By: Carl W. Vogt
Chairman