National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 16, 1998

In reply refer to: R-98-54 through -57

Honorable Jolene M. Molitoris
Administrator
Federal Railroad Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 5:56 a.m., on August 9, 1997, National Railroad Passenger Corporation (Amtrak) train 4, the Southwest Chief, derailed on the Burlington Northern Santa Fe Railway (BNSF) tracks about 5 miles northeast of Kingman, Arizona. Amtrak train 4 was en route from Los Angeles, California, to Chicago, Illinois, and had just left the Kingman station. The train was traveling about 89 mph on the eastbound track when both the engineer and assistant engineer saw a "hump" in the track as they approached bridge 504.1S. They applied the train's emergency brakes. The train derailed as it crossed the bridge. Subsequent investigation revealed that the ground under the bridge's supporting structure had been washed away by a flash flood. Of the 294 passengers and 18 Amtrak employees on the train, 173 passengers and 10 Amtrak employees were injured. No fatalities resulted from the accident. The damages were estimated to total approximately $7.2 million.[1]

The National Transportation Safety Board determined that the probable cause of this accident was displacement of the track due to the erosion and scouring of the inadequately protected shallow foundations supporting bridge 504.1S during a severe flash flood because the BNSF management had not provided adequate protection, either by inspection or altering train speeds to fit conditions. Contributing to the accident was the failure of the BNSF management to adequately address the erosion problems at bridge 504.1S.

In its investigation, the Safety Board identified concerns regarding the safety of structures subject to damage in severe storms, the protection of trains during severe weather conditions, and passenger safety and emergency response procedures, among other issues. In addition, the Safety Board investigated the use of locomotive event recorders.

[1]For more detailed information, read Railroad Accident Report—*Derailment of Amtrak Train 4, Southwest Chief, on the Burlington Northern Santa Fe Railway, near Kingman, Arizona, August 9, 1997* (NTSB/RAR-98/03).

With regard to the failure of bridge 504.1S,[2] the investigation examined the adequacy of the design, maintenance, inspection, and drainage area characteristics of bridge 504.1S in light of the severe weather and flash flood conditions affecting the bridge and the subsequent failure of a crosswall and the bridge supporting structure. Bridge 504.1S was supported by a shallow foundation consisting of timber mud sills and timber blocking. BNSF records showed that the bridge supports were susceptible to scouring and erosion as early as 1959, when it was necessary to add stones and grout to a portion of the streambed. In the succeeding years, additional stones and grouting were added. Records also showed that, in 1975, maintenance personnel were still concerned about the bridge supporting structure and its water-carrying capacity. In fact, they remained so concerned that they recommended that the bridge be placed on the Capital Improvement Program (CIP) list for replacement.

BNSF bridge records identifying the size of the drainage area for bridge 504.1 were inconsistent. One record showed the drainage area as encompassing 3.8 square miles, while another showed the drainage area as totaling 19.09 square miles. The size of the drainage area is an important element in determining the required waterway opening for drainage structures. After the accident, the BNSF's consultant (HDR Engineering, Inc.) determined that the drainage area for bridge 504.1 was 19.5 square miles. The consultant's report cited the accepted engineering practice of using the 100-year storm criteria to provide for drainage structures but noted that local conditions and circumstances, such as the desert nature of the Kingman area, allowed for making an engineering judgment resulting in higher or lower values. According to the consultant's report, the bridges located at milepost 504.1 at the time of the accident were capable of withstanding a 24-year storm. The storm related to this accident was determined to have been approaching a 50-year storm event of 2 hours' duration. (The August 9, 1997, storm's effect differed among the five railroad bridges in the area. Bridge 504.1 experienced an approximate 50-year storm event, while bridge 503.7, for example, experienced an approximate 10-year storm event.)

In 1975, railroad management placed bridge 504.1 on the 1977 CIP replacement program because the results of engineering studies raised concerns about the bridge's ability to provide an adequate waterway opening and about recurring erosion problems. In early 1976, however, railroad bridge maintenance personnel made a field decision to build an unreinforced concrete crosswall on the downstream side of bridge 504.1. Bridge 504.1 was subsequently removed from the 1977 replacement program.

Only two instances of high water were recorded for bridge 504.1 and both took place in 1976. This was after 1971 work affecting the box culverts downstream from the BNSF bridges had been performed by the Arizona Department of Transportation and after bridge 504.1 had been removed from the CIP budget list. Before the 1997 derailment at bridge 504.1S, no accidents involving high water or bridge failure were recorded for the Kingman area.

The purpose of the unreinforced concrete crosswall was to allow silt to back up and accumulate around the mud sills, thus acting to mitigate further scouring and erosion. However,

[2]The BNSF designates bridges by their milepost numbers. There are two separate bridges at milepost 504.1; one for the eastbound track and another for the westbound track. The bridges are designated by the BNSF as the south and north bridges, respectively.

no engineering evaluation was performed on the design and construction of the unreinforced concrete crosswall to determine the necessary anchorage, the appropriate size, the need for reinforcement, or the hydrologic characteristics of the waterway.

The severe flash flooding and resultant stream flow between bridge 504.1 and Arizona State Route 66 caused severe erosion that rapidly progressed upstream. The Safety Board cannot determine whether channel improvements made in 1971 contributed to this development, but evidence of streambed erosion was found during the on-site investigation. This erosion progression caused the failure of the unreinforced concrete crosswall because it was not anchored and was only 33 inches in depth. Because it was unreinforced, the crosswall broke into several pieces when its shallow footing was undermined.

When the concrete crosswall failed, the rate of erosion accelerated through the accumulated silt to the point that it quickly progressed to the shallow foundation of the bridge. This process undermined the bridge's mud sills and timber blocking and compromised the bridge's ability to support Amtrak train 4. The Safety Board therefore concluded that the failure of the bridge 504.1S was caused by scour and erosion affecting the inadequately protected shallow foundations that supported the bridge; the scour resulted because a poorly designed concrete crosswall was built instead of a new and better-engineered bridge.

The Safety Board also investigated the issue of the protection of trains during severe weather conditions. The Safety Board acknowledges the prompt action taken by the FRA in issuing its Safety Advisory 97-1 for special inspection procedures for bridges, following the Kingman accident. The Safety Board, however, is concerned because the items listed in the FRA's advisory are only recommended; they are not regulatory requirements. When issuing the advisory, the FRA cited the Track Safety Standards (49 *Code of Federal Regulations* 213), which state in part, "In the event of fire, flood, severe storm, or other occurrence which might have damaged track structure, a special inspection must be made of the track involved as soon as possible after the occurrence…" as justification for the advisory. The FRA stated that it purposely made this provision general in nature, because, "It is not practicable to specify in a minimum safety standard all the conditions which could trigger a special inspection, nor the manner in which any particular special inspection must be conducted." The FRA believed, "It is more effective to provide information and guidance to the railroad industry, which each railroad can then adapt to its own circumstances."

Although bridge inspections during severe weather circumstances are not mentioned in the FRA's Track Safety Standards, it appears that the FRA assumes that the language in Part 213.239 is a "catch-all" for everything that should be done but is not specifically addressed. Had the FRA's Safety Advisory 97-1 been in effect before the accident, the BNSF may have: had a program in place to identify those bridges that had specific features susceptible to damage in severe weather; analyzed the potential for damage to those bridges; and made that information available to those responsible for inspecting the bridges in such situations.

In the Kingman accident, however, the track supervisor did not have this type of information before the accident. If he had had this information, he should have been able to recognize the susceptibility of bridge 504.1S to damage during the severe flash flooding and could

have taken action to stop trains until an appropriate inspection could be made by a bridge inspector; alternatively, he could have halted train traffic until the water subsided and it could be determined that the bridge was not in danger. The Safety Board concluded that, had the FRA issued minimum standards for special inspection procedures for bridges that would be at risk during severe weather, such as those standards recommended in its Safety Advisory 97-1, the BNSF track supervisor would have had better guidance for making the special inspection. Because the FRA issued the safety advisory as an informational guideline, it has already taken the first step in specifying some minimum safety standards for bridge inspection.

Passenger safety in emergency conditions was another concern raised by the Kingman accident. The failure of emergency electrical systems to provide emergency power can be a serious problem in critical situations such as derailments. The emergency electrical system for each passenger car on train 4 was either at minimal output or at no power as a result of the derailment. Extensive undercarriage damage resulted in severed wiring and electrical conduits. Consequently, neither the interior emergency lights nor the public address system was reliable for operation, and no back-up system was provided. Passengers either had to rely on the instructions they were given by the Amtrak personnel in their car or to evacuate the train on their own.

In the Kingman accident, the Amtrak light sticks provided sufficient emergency lighting until the arrival of emergency responders. Light stick use was limited, but the usefulness of the light sticks was well acknowledged by the passengers, and they provided a measure of safety when the emergency lighting failed. The Safety Board is concerned, however, that not enough is being done to provide for passenger safety when emergency power is lost. In the 1996 Silver Spring accident,[3] a contributing factor to the severity of the accident and the loss of life was the lack of appropriate regulations to ensure adequate emergency egress features on railroad passenger cars. One of the safety recommendations issued following this investigation called for the FRA to:

> R-97-17
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> Require all passenger cars to contain reliable emergency lighting fixtures that are each fitted with a self-contained independent power source and incorporate the requirements into minimum passenger safety standards.

On February 25, 1998, the FRA responded to this safety recommendation, stating that:

> FRA findings in recent accidents support the Safety Board's implied concern that placement of electrical conduits and battery packs below the floor of passenger coaches can result in damage that leads to the unavailability of emergency lights precisely at the time they are most needed. However, from initial investigation it is not certain whether current 'ballast' technology provides illumination of sufficient light level quality with reliable maintainability.

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[3]Railroad Accident Report—*Collision and Derailment of Maryland Rail Commuter* MARC *Train 286 and National Railroad Passenger Corporation* Amtrak *Train 29 Near Silver Spring, Maryland, on February 16, 1996* (NTSB/RAR-97/02).

At a meeting in December 1997, the FRA delegated this issue to its Railroad Safety Advisory Committee for Passenger Equipment Safety Standards Working Group and stated that this group will aggressively pursue this option for more reliable emergency illumination. The status of Safety Recommendation R-97-17 is "Open—Response Received."

The Safety Board concluded that passenger car interiors must have interior emergency lighting because a sufficient quantity of light sticks may not always be available, and light sticks may not be suitable for a large-scale evacuation such as the one that occurred in this accident. In addition, while the light stick may serve adequately as a personal emergency light source during an evacuation, it is not a self-contained emergency lighting source. Therefore, the Safety Board reiterated Safety Recommendation R-97-17 to the FRA.

The Kingman derailment also raised issues concerning seat securement. Inspection of train 4's seats indicated that none had become separated from their floor mountings. However, 18 seat assemblies were found with their rotating locking mechanisms not engaged. A disengaged seat lock can result in an uncontrolled rotation of the seat assembly, even in cases of a minor derailment, which may result in serious injuries to passengers. In the August 23, 1990, Batavia, Iowa,[4] accident report, the Safety Board stated its concern regarding Amtrak's seat locks and noted that seats can become unlocked either because the locking mechanisms are disengaged en route by passengers or because they are defective. The Safety Board issued the following safety recommendation to Amtrak:

> R-91-71
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> Implement procedures for on-board-service personnel to periodically check passenger seats en route for unlocked anti-rotational devices and take action to ensure seats are functional.

On May 22, 1992, this safety recommendation was classified "Closed—Acceptable Action," based on Amtrak's response that it was immediately issuing instructions systemwide to check and ensure that seat locks are functional and engaged.

Absolute assurance is not always possible, however, because passengers can readily disengage the mechanism to rotate the seat to suit their personal requirements and may fail to ensure that the locking mechanism is again positively engaged. Further, on-board service personnel may not be able to provide the constant vigilance necessary to ensure that the seat locking mechanisms have been properly restored, because the seat locking mechanism is not readily visible. The Safety Board concluded that the current procedures used to check and ensure that passenger car seat locks are functional and engaged are inadequate. A simple solution may be to employ a positive locking mechanism that requires use of a special keying feature accessible only to crewmembers (such as a conductor's coach key). This procedure could provide for seat locking security and effectively eliminate manipulation by passengers.

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[4]Railroad Accident Report—*Derailment of Amtrak Train No. 6 on the Burlington Northern Railroad, Batavia, Iowa, April 23, 1990* (NTSB/RAR-91/05).

Finally, the Safety Board's investigation of the Kingman accident indicated that improvements could be made in the use of locomotive event recorders. The problem of mismatched software readout programs being used to read event recorder information is not new to the Safety Board. Hundreds of software readout programs and versions of those programs are used to read out today's solid-state event recorders. The Safety Board laboratory is constantly updating its readout programs to keep current with the many programs and software revisions as they evolve. Unlike magnetic tape recorders, solid-state event recorders can only be read out using a computer and appropriate software. Therefore, it is imperative that event recorder data be read out using the correct software, to ensure that all the recorded data are extracted and that the data are accurate.

In this particular accident, however, Amtrak did not have the capability to read out all the data on its own recorders. Amtrak was unaware that valuable additional data had been recorded on its event recorders; six more parameters were actually recorded but not extracted by the Amtrak Integrated Function Computer analysis program. These parameters provide data about the operational characteristics of the train important for performing an accurate accident investigation. The Safety Board therefore concluded that, had Amtrak been more familiar with the specifications of the event recorders on train 4, it could have obtained additional information from them that would have been useful.

The FRA, in conjunction with the railroads and recorder/software manufacturers, is responsible for ensuring that all recorded data can be accurately and reliably retrieved after any train accident. No industry-wide procedures or Federal regulations address documentation of locomotive event recorders or readout system specifications. These specifications are necessary to conduct accurate readouts of event recorders. Physical inspections of the locomotive to determine the recording system specifications can be impractical or, in the case of severe accidents, impossible, because of component damage.

Therefore, event recorder system specifications should be kept as part of the locomotive's records. These records should be readily accessible for FRA or Safety Board inspection and must be kept up to date. These records should include, at a minimum: (1) the name, version, and date of the readout program intended for use with the recorder currently installed on the locomotive; (2) the manufacturer, model number, and serial number of the event recording device and its associated components (to include the air brake manifold, axle generator or equivalent, and signal conditioning devices) currently installed on the locomotive; (3) a complete list of parameters that the recording system is currently configured to record; and, (4) the recording system's manufacturer-prescribed modification, revision, and software-hardware version numbers.

Therefore, the National Transportation Safety Board makes the following safety recommendations to the Federal Railroad Administration:

> Require that all railroads identify and perform a one-time risk assessment of the bridges on their systems that have shallow foundations of similar construction to the bridge 504.1 that failed in the Kingman, Arizona, accident, and require replacement of those bridges determined to be susceptible to undermining and loss of the supporting foundation structure. (R-98-54)

Incorporate the intent of Safety Advisory 97-1 into minimum safety standards for special inspection procedures for bridges that would be at risk during severe weather. (R-98-55)

Include in the passenger car safety standards a requirement for positive seat securement systems to provide against the disengagement and undesired rotation of seats in all new passenger cars purchased after January 1, 2000, and require the incorporation of such a system into existing passenger cars when they are scheduled for overhaul. (R-98-56)

Require that event recorder system specifications be kept as part of the locomotive's records. (R-98-57)

Also, the Safety Board issued Safety Recommendations R-98-48 through -53 to the Burlington Northern Santa Fe Corporation, H-98-41 to the Federal Highway Administration, H-98-42 to the Arizona Department of Transportation, R-98-58 through -61 to the National Railroad Passenger Corporation (Amtrak), R-98-62 to the Mohave County Sheriff's Department, R-98-63 to the International Association of Chiefs of Police, R-98-64 to the National Sheriffs' Association, R-98-65 to the Association of American Railroads, and R-98-66 to the American Short Line and Regional Railroad Association.

Please refer to Safety Recommendations R-98-54 through -57 in your reply. If you need additional information, you may call (202) 314-6430.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

[Original Signed]

By: Jim Hall
Chairman