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RAILROAD SPECIAL INVESTIGATION REPORT

DERAILMENT OF AMTRAK TRAIN NO. 12 AND SIDESWIPE OF AMTRAK TRAIN NO. 79 ON PORTAL BRIDGE NEAR SECAUCUS, NEW JERSEY, NOVEMBER 23, 1996

6813B

Abstract: On November 23, 1996, the National Railroad Passenger Corporation (Amtrak) train No. 12 derailed while crossing Portal Bridge, a swing bridge spanning the Hackensack River in Secaucus, New Jersey. When the train derailed, it sideswiped Amtrak train No. 79, which was crossing the bridge in the opposite direction on an adjacent track. No fatalities resulted, but 42 passengers and crewmembers aboard train No. 12 were injured, as was 1 passenger aboard train No. 79. Estimated cost of the damaged train, track, and signal equipment and site cleanup exceeded $3.6 million.

The safety issues discussed in this report are (1) Amtrak management oversight of the inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge; and (2) the effectiveness of Amtrak's emergency notification procedures. The report also examines the effectiveness of Amtrak locomotive event recorders in capturing critical operational data.

As a result of its investigation, the National Transportation Safety Board issued safety recommendations to Amtrak, the Federal Railroad Administration, the Association of American Railroads, and the American Short Line Railroad Association.

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RAILROAD SPECIAL INVESTIGATION REPORT

Adopted: December 18, 1997
Notation 6813B

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C. 20594

CONTENTS

EXECUTIVE SUMMARY

About 6:28 a.m. on Saturday, November 23, 1996, eastbound National Railroad Passenger Corporation (Amtrak) train No. 12 derailed while crossing Portal Bridge, a swing bridge spanning the Hackensack River in Secaucus, New Jersey. When the train derailed, it sideswiped Amtrak train No. 79, which was crossing the bridge in the opposite direction on an adjacent track. All 12 cars of train No. 12 derailed, with both locomotives, 1 material handling car, and the 3 head passenger coaches coming to rest at the bottom of an embankment at the east end of the bridge. Train No. 79 sustained damage but was able to stop with the entire train intact and on the rails some distance west of Portal Bridge. No fatalities resulted from the accident, but 42 passengers and crewmembers aboard train No. 12 were injured, as was 1 passenger aboard train No. 79. Estimated cost of the damaged train, track, and signal equipment and site cleanup exceeded $3.6 million.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of Amtrak management to foster an environment that promoted adequate inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge and to permanently correct defects in the miter rail side bars that were discovered 10 months before the accident. Contributing to the accident were (1) the failure of the Federal Railroad Administration to develop track inspection standards for special trackwork and to periodically inspect such track as part of its oversight responsibilities and (2) Amtrak's removal of the miter rail position detection circuitry without installing replacement circuitry or implementing procedures to compensate for the loss of this safety-critical system.

The two primary safety issues discussed in this report are: (1) Amtrak management oversight of the inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge; and (2) the effectiveness of Amtrak's emergency notification procedures. The Safety Board also examined the effectiveness of Amtrak locomotive event recorders in capturing critical operational data.

As a result of its investigation of this accident, the Safety Board makes safety recommendations to Amtrak, to the Federal Railroad Administration, to the Association of American Railroads, and to the American Short Line Railroad Association.

INVESTIGATION

Synopsis

About 6:28 a.m. on Saturday, November 23, 1996, eastbound National Railroad Passenger Corporation (Amtrak) train No. 12 derailed while crossing Portal Bridge, a swing bridge[1] spanning the Hackensack River in Secaucus, New Jersey. (See figure 1.) When the train derailed, it sideswiped Amtrak train No. 79, which was crossing the bridge in the opposite direction on an adjacent track. All 12 cars of train No. 12 derailed, with both locomotives, 1 material handling car, and the 3 head passenger coaches coming to rest at the bottom of an embankment at the east end of the bridge. Train No. 79 sustained damage but was able to stop with the entire train intact and on the rails some distance west of Portal Bridge. No fatalities resulted from the accident, but 42 passengers and crewmembers aboard train No. 12 were injured, as was 1 passenger aboard train No. 79.

Preaccident Events

Amtrak train No. 12 departed Washington, D.C., at 3:00 a.m. on November 23, 1996, en route to Boston. The train consisted of two locomotives, seven passenger coaches, and five material handling cars loaded with mail. The train changed crews (an engineer, conductor, and assistant conductor) in Philadelphia, departing that station at 5:10 a.m.

Also early in the morning of November 23, Amtrak train No. 79 was made up in Sunnyside Yard, Queens, New York, with one locomotive and nine passenger coaches. A baggage car was added to the rear of the train at Pennsylvania Station in New York, and at 6:15 a.m. the train departed Penn Station en route to Charlotte, North Carolina. The crew consisted of an engineer, a conductor, and two assistant conductors.

At 4:00 a.m. on November 23, the bridge operator on duty at Portal Bridge received a radio call from a tugboat asking that the bridge be opened to allow the vessel to proceed north up the Hackensack River. At 4:03 a.m., according to the bridge event recorder, the bridge operator received the “unlock” from the on-duty Amtrak train dispatcher in New York City.[2]

The bridge operator stated that the bridge unlocking function sequenced normally, but that when he attempted to open the bridge by rotating its center section counterclockwise, he was unable to do so. The bridge operator noted the problem in the bridge log book. The log book indicated that the bridge was electrically locked at 4:10 a.m. According to telephone transcripts, the bridge operator called the train dispatcher at 4:15 a.m.[3] and told him

> It’s locked up now. I had a real hard time lining it up…. [T]his thing [was] rocking like it never rocked before, and…I just don’t want to take any chances. It’s all locked up now.… It’s all closed; you should be able to lock it up.

The bridge event recorder indicated that the train dispatcher reassumed electrical control of the bridge at 4:17 a.m. After his call to the on-duty train dispatcher, the bridge operator called the Amtrak bridge and building (B&B) department electrical foreman[4] and then, at 4:20 a.m., the assistant chief train dispatcher. He told the assistant chief dispatcher

[1]The center portion of the bridge could be rotated up to 90° to permit the passage of river traffic.

[2]The bridge operator could operate the bridge only after the authority and the means had been provided by the train dispatcher. By sending an “unlock” signal, the train dispatcher made electrical power available so that the bridge operator could open and close the bridge.

[3]The bridge event recorder and telephone transcripts are not synchronized and vary by a few minutes.

[4]The bridge operator stated that he called an electrician because about 1 week earlier, the bridge had experienced a problem with the swing brakes, and he assumed that this latest malfunction was brake-related.

Figure 1- Looking south over Amtrak's Portal Bridge spanning the

Hackensack River near Secaucus, New Jersey

I can't even describe it. I never had this…happen before. I'm giving the release, and I've got all my indications that everything is fine on the board [control panel] as far as my brakes and my swing go, but as soon as I swing, the thing goofs up on me…. This bridge is really rocking…back and forth—it almost seems like the thing is going to crack….

At 4:22 a.m., the assistant chief train dispatcher relayed this information via telephone to the Amtrak communication and signal (C&S) department trouble desk.

In response to the bridge operator's call to the B&B department electrical foreman, a B&B electrician arrived at the bridge about 5:40 a.m. to troubleshoot the bridge's brakes and control circuits and determine why the bridge would not open. He approached the bridge from the west end and walked on the north side of track 2. He stated that the west end of the bridge was fully illuminated and that he did not see anything unusual. In the meantime, at 5:50 a.m., the bridge operator called the train dispatcher and requested a bridge unlock so that he could make a test. The electrician said that he went up to the bridge operator's control room to check the bridge swing brakes electrically. When he learned that the bridge had been unlocked, he asked the bridge operator to call the train dispatcher to request that the bridge be locked again so that he (the electrician) could physically inspect the brakes below the bridge before another opening was attempted. The train dispatcher responded by

Neither the bridge operator nor the B&B technician was aware that, during the aborted bridge opening, a 10-foot 6-inch movable section of the north rail of track 1 became improperly aligned. While the west-facing portion of the rail section mated properly with the rail on the approach to the bridge, the trailing end was elevated 5 inches above the track with which it was supposed to align. (See figure 2.) As a result, the right lead truck of any *westbound* train crossing Portal Bridge on track 1 would have struck the elevated butt end of the misaligned rail, and the left lead truck of any *eastbound* train would ride up the "ramp" created by the rail and then drop off the elevated end. Because the mitered end of the rail was positioned properly and electrical continuity was maintained throughout the misaligned rail, the signals governing train movements along track 1 over the bridge continued to display a clear aspect.

Figure 2 — Looking west at the west end of track 1. The heel of the miter rail is elevated about 5 inches above the running rail, creating a ramp for the left side trucks of any eastbound train. (Photograph taken on the day of the accident after removal of the derailed equipment.)

The Accident

At 6:19 a.m., the train dispatcher called to notify the Portal Bridge operator that a train (train No. 79) was leaving Penn Station westbound (toward the bridge) on track 2. At 6:24 a.m., the dispatcher called to advise the bridge operator that an eastbound train (train No. 12) was approaching the bridge on track 1. Meanwhile, although it was dark, the B&B electrician had visually inspected the bridge swing brakes and, judging them to be normal, went back to the bridge operator's control room to make a second electrical brake check.

Locomotive event recorder data indicated that as eastbound train No. 12 approached the Portal Interlocking[5] on track 1, the engineer reduced the train's speed from 90 mph to 62 mph, which was below the 70 mph permanent timetable speed restriction in force for movements through the interlocking on both main tracks. Event recorder data indicated that as westbound train No. 79 approached Portal Interlocking on track 2, its engineer reduced the train's speed from 90 mph to 67 mph.

At about 6:28 a.m., the lead locomotive of eastbound train No. 12 rolled onto the "ramp" created by the misaligned rail section. Both locomotives and all 12 following cars derailed and, with emergency train brakes having been applied by the engineer, the train continued eastward about 1,060 feet. The engineer of approaching train No. 79 observed "extreme wheel sparking" as train No. 12 moved east, at which time train No. 12's engineer radioed, "Emergency! Everything east and west of Portal! All Stop! All Stop!" Train No. 79's engineer also reported that his train had initiated emergency braking. Train No. 79 was struck along its south side by equipment of the still-moving train No. 12 as the trains passed on the bridge. The impact caused some of the air brake hoses between the cars on train No. 79 to separate, initiating an automatic emergency brake application.

Train No. 79 sustained sideswipe damage but stopped with the entire train intact and on the rails west of Portal Bridge. Train No. 12 came to rest with both locomotives, one material handling car, and the three head passenger coaches entirely derailed and located in various positions to the south of track 1 and down the embankment at the east end of the bridge. (See figure 3.) The remaining eight cars of train No. 12 remained upright and in line, but they were all or partially derailed.

At the time of the derailment, the B&B electrician was in the bridge control room talking on the telephone with someone from the C&S trouble desk who had called to determine if the problem with the bridge had been identified. A C&S signal maintainer was on duty in a work trailer just west of Portal Bridge when the derailment occurred. He said he heard what sounded like a "rough ride" on the bridge. According to telephone transcripts, at 6:35 a.m., the C&S maintainer contacted the C&S trouble desk and reported trouble at the bridge. He was told that train No. 12 had reported derailing and that train No. 79 may have derailed also. The C&S maintainer asked if the bridge had been opened. He was told about the failed attempt to open the bridge earlier that morning and was told that the bridge had been reported locked again after the attempt, but that no one had visually confirmed that it was, in fact, properly aligned and locked.

After the C&S maintainer inspected the bridge, he reported back to the C&S trouble desk that

> The heel of the miter rail[6] is driven up in the air. Now, the front part of it, where we [get] our [signal] indication, that's down…so [our signals] indicate that the rail is down. But the back part of [the rail]…is in the air.

[5] An *interlocking* is an arrangement of signals and control apparatus so interconnected that functions must succeed each other in a predetermined sequence, thus permitting train movements along routes only if safe conditions exist. Portal Bridge was located within the confines of the Portal Interlocking.

[6] One of the eight (two for each track on each end of the bridge) movable rails located at the junction of the fixed and movable spans of the bridge. During bridge opening, the miter rails were mechanically raised, freeing the center bridge span to rotate.

Figure 3 – Wreckage of train No. 12 at the east end of Portal Bridge

Survival Factors

Emergency Response -- According to telephone tape transcriptions, at about 6:36 a.m., Amtrak's assistant chief train dispatcher notified Amtrak's National Police Dispatching Center (NPDC) in Philadelphia that train No. 12 had derailed on Portal Bridge over the Hackensack River. The train dispatcher stated that police and emergency personnel would be needed at the scene.

Amtrak's computerized geographical data base indicated that the derailment fell within the Secaucus police area and that the closest access roads east and west of the site were County Road and Belleville Road. The NPDC dispatcher called the Secaucus Police Department at 6:40 a.m. and said that an Amtrak train had derailed at "Portal Tunnel" between County Road and Belleville Road. The Secaucus police officer told the Amtrak police dispatcher that Portal Tunnel was located at the Bergen Interlocking (which is about 3 miles east of Portal Bridge) in North Bergen, New Jersey, and was outside Secaucus police jurisdiction.

At 6:42 a.m., the Amtrak police dispatcher called the North Bergen Police Department, reported the derailment, and described the accident location as being between County Road and Belleville Road at the "Portal Tunnel Bridge." The North Bergen police told the Amtrak police dispatcher that that location was in Jersey City in Secaucus jurisdiction and not in the North Bergen area.

At 6:44 a.m., the Amtrak police dispatcher called the Secaucus police again and related his conversation with the North Bergen police. The Amtrak dispatcher and the Secaucus police discussed the fact that the Portal Bridge spans the Hackensack River and that the Amtrak data base showed the closest access roads as County and Belleville. At 6:47 a.m., a Secaucus police unit was dispatched to check bridges in the area, but Portal Bridge was not checked.[7] At about 6:54 a.m., a construction worker from a construction site near the bridge flagged down a Secaucus police patrol car and directed its two officers to the accident location. A short time later, another patrol car with two more police officers was dispatched to the scene.

Shortly after the initial identification of the accident location, the Secaucus police called the NPDC and said that the Secaucus police had located the accident site. The caller told the NPDC how access had been gained to the site and provided a preliminary assessment of injuries. About 18 minutes elapsed between the time the NPDC was notified of the accident and the time the first police officers arrived on the scene. The first ambulance arrived on the scene about 47 minutes after the initial notification.

Once at the bridge location, emergency responders had difficulty accessing the actual accident site. Some of the emergency vehicles approached the bridge from the west, but because the wreckage was on the east end of the bridge, they had to be rerouted to the other side.

Responding to the accident were the Secaucus and Jersey City Fire Departments; the Secaucus, Jersey City, and Amtrak Police Departments; the Secaucus Emergency Management Agency; and Jersey City Medical Center Emergency Medical Services.

The Secaucus Fire Department received a call about 6:57 a.m. to respond to a train derailment and assist in opening passenger windows on the derailed cars. The department dispatched one engine company, one truck company, one rescue company, the fire chief, and two assistant fire chiefs. The firefighters were directed to the accident site by a police official and arrived about 7:04 a.m. Upon arrival, the fire units established a mobile incident command post and surveyed the scene. The fire chief later stated that he was advised by a railroad employee that no one was on board the train, but that he ordered a search of all the cars.

At about 7:05 a.m., the Jersey City Fire Department arrived. The Jersey City and Secaucus fire chiefs communicated on different radio frequencies, but they were able to establish a unified command post after several minutes. The Jersey City Office of Emergency Management dispatched 12 units and 27 personnel at 7:02 a.m. All units began arriving at the accident scene at 7:08 a.m. The Jersey City Fire Department was dispatched to the accident

[7]Secaucus police officials told the Safety Board they were not familiar with Portal Bridge.

scene at 7:18 a.m., and all 34 personnel arrived at 7:28 a.m. Four engines, two trucks, one rescue unit, one squad unit, one car, the division chief, and the battalion chief responded to the accident.

While on patrol, a Jersey City police car heard a report of the derailment on the radio with the possible location being on the Jersey City and Secaucus border. The police officer arrived and found seven cars derailed on the east side of the bridge. The officer saw that many, if not most, of the passengers had gotten off the train, and he was told that one person was still on the train being treated by train personnel. The officer located that person, who was being ministered to by train personnel and a unit from the Jersey City Medical Center. The officer advised his department of the best way to access the accident site and requested help from the emergency services unit to check the remainder of the train for additional injuries. A sergeant from emergency services arrived and took control of securing and removing injured passengers. A police lieutenant of the Jersey City Police Department was in charge of all police personnel on the scene.

The Jersey City Police Department dispatched six patrol cars, one K-9 unit, one motorcycle unit, five emergency medical services units, the tour commander, the city captain, and the deputy police director. About 20 police department personnel responded to the accident. Units were dispatched to the accident scene starting at 7:16 a.m., with all units arriving by 7:29 a.m.

Emergency Preparedness -- The Hudson County Emergency Operating Center was opened and the staff maintained communications with the accident scene coordinator and disseminated information about the accident to State and county officials and the press. Hudson County implemented the emergency response plan that had been prepared by the Hudson County Office of Emergency Management and approved by the New Jersey State Police Office of Emergency Management in December 1995.

Local officials told the Safety Board that full-scale disaster drills and simulated "table top" exercises (without the use of train equipment or mock evacuations) are regularly held in Hudson County and all of its municipalities. Before this accident, the most recent exercise had been held on November 9, 1994, simulating a hazardous materials accident.

Injuries

Table 1 is based on the injury criteria (49 *Code of Federal Regulations* (CFR) 830.2) of the International Civil Aviation Organization, which the Safety Board uses in accident reports for all transportation modes. The number of reported injuries reflects only the crewmembers of train 12 and those individuals transported to a medical facility.

Table 1. — Injuries resulting from the Portal Bridge derailment

Injury Type	Train 12 Crew	Train 79 Crew	Passengers Train 12	Passengers Train 79	Deadhead Employees[1] (Train 12)	Total
FATAL	0	0	0	0	0	0
SERIOUS	0	0	0	0	2	2
MINOR	2	0	17	1	22	42
NONE	1	4	73[2]	161	0	239
TOTAL	3	4	90	162	24	283

[1]Railroad employees traveling from one terminal to another in nonrevenue service.
[2]Two people traveling in train No. 12 in unknown capacities refused treatment.

Damages

From information provided by Amtrak, the Safety Board estimated the cost of the damaged train, track, and signal equipment and site cleanup to exceed $3.6 million. Damages to train No. 12 included both locomotives, seven passenger cars, and five material handling cars. Damages to train No. 79 were limited to the locomotive, three passenger cars, and a baggage car.

Personnel Information

Traincrews -- The investigation determined that the engineer, conductor, and assistant conductor of train No. 12 and the engineer, conductor, and both assistant conductors of train No. 79 were rested in accordance with the Federal Hours of Service Law. Additionally, all were qualified on the operating rules and physical characteristics of the territory.

Portal Bridge Operator -- The 38-year-old bridge operator was hired by Amtrak as a trackman on April 3, 1980. He was rated qualified as a bridge operator in 1985 and had been the bridge operator at Portal Bridge for about 4 years prior to the accident. He was not designated by Amtrak as an employee responsible for supervising track maintenance or renewals or for inspecting track. He therefore was not, and was not required to be, qualified on Amtrak's maintenance of way (MW) 1000, *Specifications for Inspection, Construction and Maintenance of Track*; nor was he qualified, or required to be qualified, for track inspection and maintenance supervision duties under 49 CFR 213.7, "Designation of qualified persons to supervise certain renewals and inspect track." According to Amtrak officials, all bridge operators are given cursory training on inspection of bridge fender systems, wedges, and miter rail systems.

The bridge operator had been off duty for 2 days before reporting for work at 11:00 p.m. on November 22, 1996. At the time of the derailment, he had been on duty for about 7 hours and 28 minutes.

Bridge and Building Electrician -- The 52-year-old electrician was hired by Amtrak on November 3, 1980. His regular duty hours were 7:00 a.m. to 3:30 p.m., Monday through Friday. He received a trouble call from the electrical foreman about 4:50 a.m. on November 23, 1996, and had therefore been on duty for almost 1 hour and 40 minutes when the derailment occurred. He had been off duty for 13 hours and 20 minutes prior to this call to service. He was not designated by Amtrak as a person responsible for supervising track maintenance and renewals or for inspecting track under the provisions of 49 CFR 213.7, and he was not, nor was he required to be, qualified on Amtrak's MW 1000.

Train Information

Both accident trains used AEM-7 electric locomotives built by General Motors Electro-Motive Division in 1980. Each locomotive was equipped with multiple traction motors totaling 7,000 horsepower. The traction motors received power from overhead electric catenary.

Train No. 12 -- Train No. 12 consisted of two locomotives numbered 910 and 901; five material handling cars numbered 1565, 1506, 1404, 1510, and 1415; six Amfleet I coaches numbered 21647, 21637, 21095, 21195, 21648, and 21125; and one Amfleet I café car numbered 43043. Amtrak records show that a mechanical test was performed on the two locomotives at 2:00 p.m. on November 22, 1996, and that no defects were found. An air brake test was performed at 2:26 a.m. on November 23, 1996, with no exceptions noted.

Train No. 79 -- Train No. 79 consisted of one locomotive, No. 930; Amfleet coaches numbered 44969, 21989, 21285, 21007, 21652, 21137, 21651, and 25026; and Amfleet dinette number 202381. At Pennsylvania Station in New York City, one baggage mail car, No. 1244, was added to the rear of the train. Amtrak records show that a mechanical test was performed on locomotive No. 930 at 3:00 p.m. on November 22, 1996, and that no defects were found. On November 23, 1996, at 5:15 a.m., train No. 79 received an initial terminal air brake test. No exceptions were noted.

Signal Information

Portal Interlocking is a remotely controlled interlocking on two main tracks. Union Switch &

Signal color position light[8] signals are supplemented with an automatic train control system under the authority of the Amtrak Section "A" train dispatcher in New York City. Portal Bridge is within the limits of Portal Interlocking. Traffic east and west of Portal Interlocking is signaled for movements in both directions. The method of operation is by timetable, by form D, by special instructions, and by signal indications.

Site Description

The derailment occurred at milepost (MP) 6.1 within the Portal Interlocking on Amtrak Northeast Corridor trackage. Amtrak designates the track through the derailment area as Federal Railroad Administration (FRA) Class 4 track, and the track leading up to the bridge met FRA Class 4 track safety standards. Although the FRA maximum allowable speed for passenger trains on Class 4 track is 80 mph, Amtrak's maximum authorized speed over the Portal Bridge was 70 mph, established by the Amtrak chief engineer in late 1992.

Portal Bridge -- Portal Bridge is a 960-foot-long steel structure with masonry abutments. The bridge consists of a 300-foot-long through-truss swing span and six (three on each side of the center span) 110-foot-long open-deck girder approach spans. Construction of the bridge was begun in August 1905, and the bridge was placed in service on November 27, 1910. Overhead catenary to supply power to electric locomotives was installed in the 1930s.

Track and Special Trackwork -- In the area of the derailment, Amtrak's Northeast Corridor consists of two main tracks. The south track is designated track 1; the north track is track 2. On the western approach to the bridge, the tracks are located in a wetland area and are constructed on an earth and rock fill, elevated about 30 feet above the Hackensack River.

Approaching the accident site from the west, track 1 is tangent (straight) from about 4,650 feet from MP W 7.0 to the point of derailment near MP 6.1 on the west end of Portal Bridge. The track continues tangent over the bridge to MP W 6.0 and for some distance beyond. At the point of derailment, it is descending with a 0.05 percent grade. The main tracks on Portal Bridge and on the bridge approach are constructed of 140-pound continuously welded rail. Guard rails are installed between the rails on both tracks for the entire length of the bridge. The purpose of the guard rails is to deflect derailed wheels away from adjacent bridge trusses.

A number of nonstandard track structures, referred to collectively as "special trackwork," are installed on Portal Bridge. Special trackwork is defined by the American Railway Engineering Association as rails, track structures, and fittings, other than plain unguarded track, that is neither curved nor fabricated before laying. The special trackwork on Portal Bridge forms the junction between the fixed rails on the bridge approach and the movable rails on the rotating center span. The special trackwork makes it possible for the rails to "disconnect" before the bridge center span is swung open and to "reconnect" after the bridge is closed.

A major component of the special trackwork is the movable miter rail assembly that actually makes and breaks the rail connections at the edge of the rotating bridge span. At the time of the accident, a single miter rail assembly[9] on the Portal Bridge movable span consisted of one 10 1/2-foot miter rail with a 31-inch tapered, or mitered, point known as the "toe"; one 11 1/2-foot side bar; one 8-foot 11-inch side bar; a section of running rail to which the miter rail was joined with the two side bars; and a base (bed) plate resting on an attaching base referred to as a "shoe." (See figure 4 – next page.) The miter rail was made of manganese steel, a much stronger steel than that used for the running rails.

[8]A fixed signal in which the indications are given by the color and position of two or more lights.

[9]There were eight miter rail assemblies (one for each end of each rail of the two tracks) on the bridge.

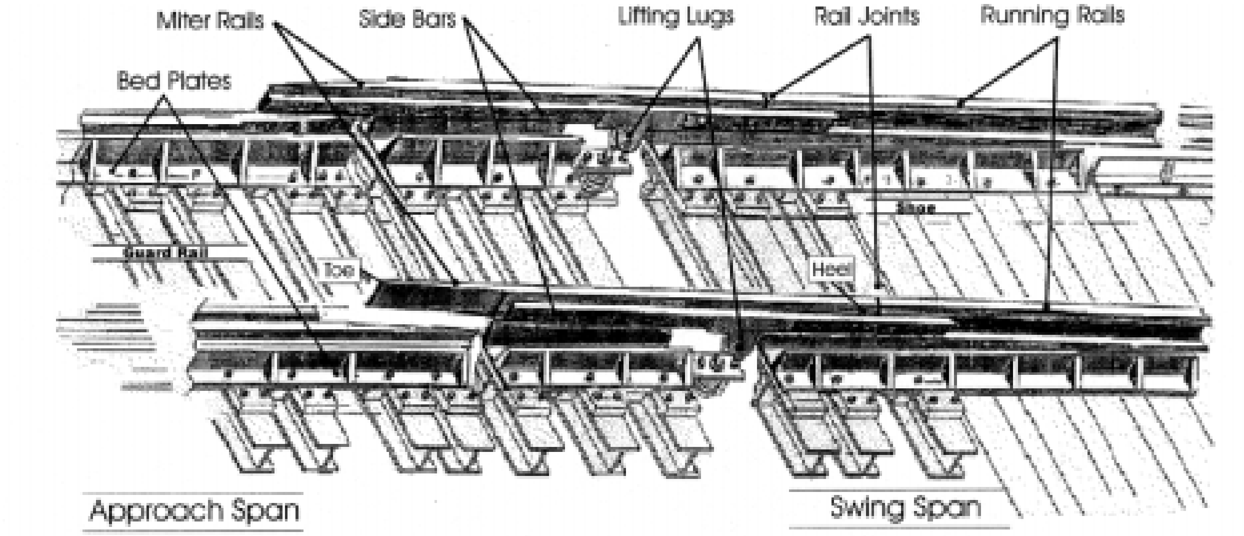

Figure 4 — Components of the miter rail assembly in place on Portal Bridge at the time of the accident

The toe (tapered end) of the movable miter rail mated with a section of fixed miter rail on the stationary spans of the bridge.[10] The other end (the square end, or "heel") of the miter rail butted against a 39-foot section of running rail. The rail sections were tied together by two side bars fastened (with 12 bolts, each 1 inch in diameter) on either side of the two rail sections across the joint. (See figure 5 – below.)

The miter rail was a 3-inch-wide solid rectangular beam. In contrast, the running rail had the standard "I-beam" (or "T") shape. To accommodate this change in cross section where the two rails joined, standard "D" bars (lengths of steel formed with one flat side and one curved side to create a D-shaped cross section) were welded to the inside of each side bar on the running rail side of the joint. The bottom edge of that portion of the side bar that was attached to the running rail was "notched," and the bottom edge of the notch was beveled to provide clearance for the base flange of the running rail. (See figure 6 – opposite.)

Figure 5 — Looking west along track 1 with miter rails in the lifted position

[10]Although both the fixed and movable sections of the mating rails were mitered, unless otherwise noted, subsequent references in this report to miter rails refer to the movable rail sections only.

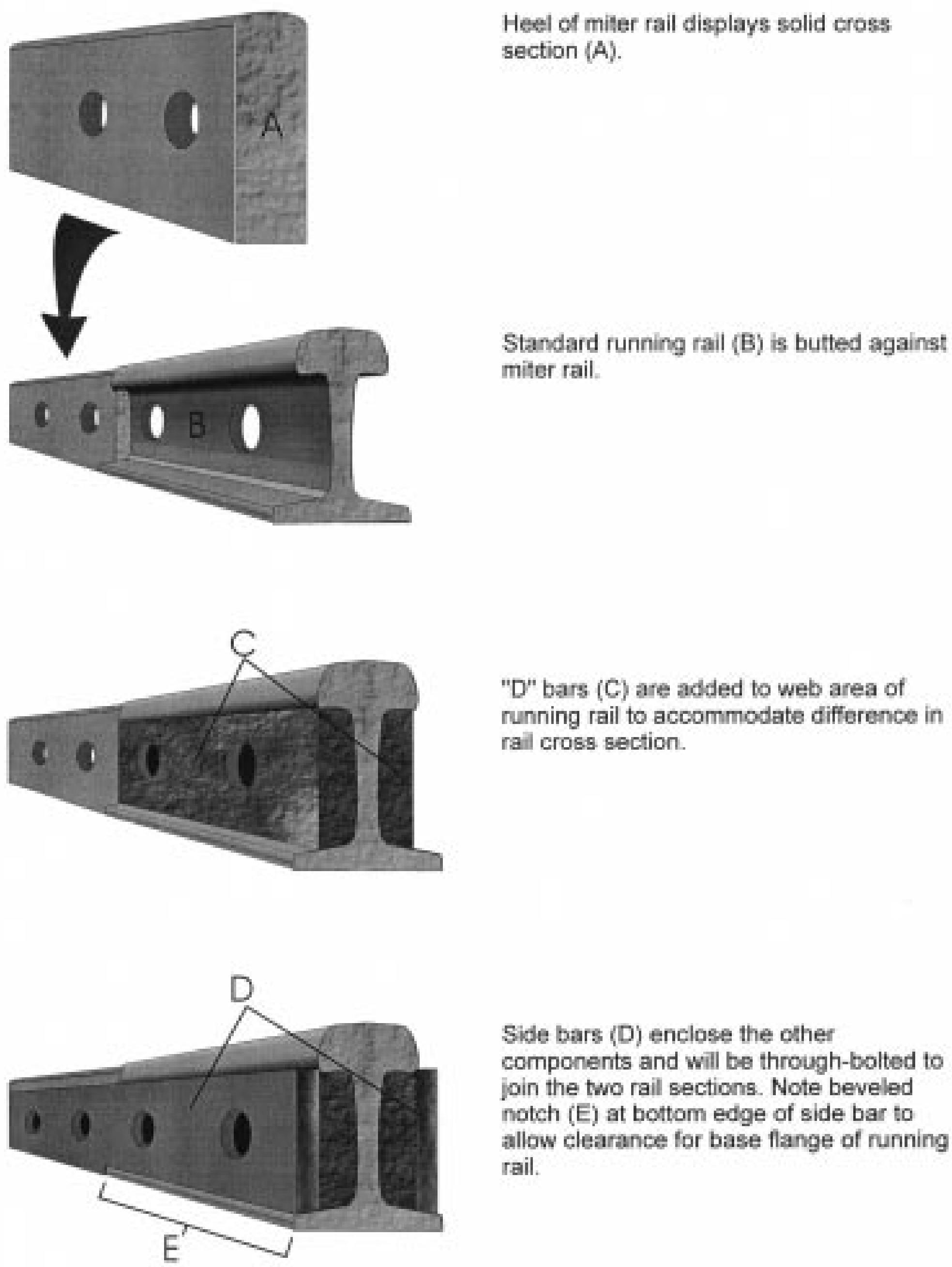

Figure 6 — Formation of the miter rail

The longer of each pair of side bars was attached to the inside, or “gauge” side of the track and extended from about 18 inches past the joint on the running rail side to the tip of the miter rail. The shorter side bar was fastened to the outside, or “field” side of the rail and extended from 18 inches past the joint on the running rail side to the beginning of the mitered portion of the miter rail. The tapered portion of the miter rail was 31 inches long, which accounts for the 31-inch difference in length between the inside and outside side bars.

The side bars had a lifting lug about 25 1/4 inches from the heel of the miter rail on the miter rail side of the rail joint. The lifting lug was connected to a vertical spring rod lift assembly underneath the bridge. Under normal circumstances, a command to open the bridge activated electric motors that drove the spring rods under all eight miter rail assemblies upward, raising the miter rails about 14 inches at the rail ends.[11] Raising the miter rails disconnected the stationary and movable rail sections and freed the center bridge span to swing open. When the bridge was closed, the spring rods were retracted, allowing the rail sections to lower. As the lowered rail sections approached the horizontal, the spring rods pulled down on the lifting lugs with a force of 2,500 pounds to fully seat the rails in the pocket of the bed plate.

Postaccident Inspection

When the locomotives and all the cars of Amtrak train No. 12 derailed, they fouled (partially blocked) track 2. Both locomotives, three passenger cars, and a baggage car came to rest on the south side of track 1 and down an embankment east of the bridge. The second, unoccupied, locomotive was positioned on its side. The three passenger coaches came to rest at various angles down the embankment.

Train No. 79 sustained minor sideswipe damage from equipment on train No. 12 fouling track 2. In addition, overhead catenary wires on both tracks were knocked down, disrupting electric propulsion. The derailment caused the closure of the Northeast Corridor at Portal Bridge and halted all Amtrak and New Jersey Transit rail operations between Newark, New Jersey, and New York City.

Wheel markings from train No. 12 were found on the field side of the south rail and the gauge side of the north rail on track 1. The markings began 31 1/4 inches east of the point of derailment. Flange marks indicated where the wheels of the derailed equipment had climbed the south rail. Wheel markings also indicated that the train wheels had struck and followed the protective guard rail installed between the rails. The track structure east of the point of derailment had been displaced by the derailed equipment, and the bridge walkway grating south of track 1 was damaged.

Examination of the bridge following the accident focused on the north rail of track 1, specifically, the joint between the miter rail and the running rail. The west-facing point of the miter rail was displaced approximately 2 1/2 inches east, but it remained seated in the bed plate on the approach span of the bridge. The side bars on either side of the miter rail joint had completely cracked through about 18 inches east of the lifting lugs, and the heel of the miter rail was resting on the broken side bars of the running rail. The resulting difference in elevation between the miter and running rails created a 5-inch ramp when viewed from the direction of travel of train No. 12 (west to east). Although misaligned, the miter rail made contact with both the stationary approach rail and the running rail on the movable span. This contact provided electrical continuity that allowed the signals governing train movements over the bridge to display a clear aspect.

Close examination of the broken side bars on the misaligned rail disclosed that about 80 percent of the break appeared to have developed sometime prior to the accident. Preliminary investigation of the other side bars on the bridge revealed that both side bars on the west end of the south rail of track 2 were cracked, as were both side bars on the east end of the south rail of track 1. After the preliminary track inspection, the misaligned miter rail was returned to its normal (seated) position to allow for the rerailing of derailed equipment.

[11] From 14 inches at the rail end, the elevation of the rail section gradually decreased until it ran out about 24 feet back from the joint between the miter and running rails (a little more than 34 feet from the rail end).

On November 24, 1996, the day after the accident, Safety Board investigators on the bridge requested that the miter rails be raised to permit close inspection of all the side bars. The following conditions were noted:

Track 1: The side bar on the field side of the east end of the south rail was cracked from the top edge into the third bolt hole along the miter rail. The crack extended for about 60 percent of the width of the side bar.

Track 2: The center of the side bar on the gauge side of the west end of the south rail was completely fractured. The side bar on the field side of the west end of the south rail was cracked from the top edge into the third bolt hole. The crack extended for about 60 percent of the width of the side bar.

Preaccident Bridge Inspections

Safety Board investigators reviewed reports of regularly scheduled track and bridge inspections that were conducted during the days and weeks preceding the accident. (For a discussion of preexisting conditions in the miter rail assemblies, see "Previous Defects In and Problems With the Miter Rail System" in the "Other Information" section of this report.)

Track inspection records for the track between MP W 3.0 and MP JC 8.0 for the period of September 2, 1996, to November 21, 1996, revealed no violations of FRA track safety standards. The records did note that the miter rails on tracks 1 and 2 on the east end of Portal Bridge were battered and needed welding and grinding.

About 10 days before the accident, track in the accident area was checked by an Amtrak track geometry test car. The track geometry exception report and script chart from that test, dated November 12, 1996, showed no exceptions taken in the vicinity of Portal Bridge.

According to the report of the annual inspection of miter and expansion joints that was conducted on June 13, 1996, the rails on Portal Bridge were ultrasonically tested for internal defects, and no defects were noted. The report did note that the rail ends on the east end of the north rail of track 1 were damaged and in need of repair.

According to Amtrak, and in accordance with 49 CFR Part 213.233, Portal Bridge trackwork receives a walking inspection at least twice weekly, with an interval of at least 1 calendar day between inspections. Because of heavy train traffic over the bridge, these inspections had been made with the miter rails in the seated, or normal, position, resting in the rail bed plates. In this position, only the head of the rail and the upper portions of the side bars were visible. A number of the bolts and nuts that secured the side bars to the joining rails were also hidden from view when the miter rails were down.

On November 22, 1996, the day before the accident, an Amtrak track inspector qualified on Amtrak's MW 1000 made a walking inspection of the tracks on the bridge. He reported no defects and noted no exceptions regarding the miter rails or their components. Track measurements taken after the accident on the gauge and cross level on the undisturbed section of the track structure at or near the point of derailment did not disclose any irregularities.

A review of Amtrak's "Monthly-Quarterly Inspection Record of Moveable Bridges" for the 3 months prior to the accident revealed that only the structural, mechanical, and electrical sections of the bridge inspection form for Portal Bridge showed completed inspections; no test bridge openings were recorded. The records indicated that the bridge ties were rated 4 ("poor, barely functioning, and needing repair"). The FRA track inspector did not take exception to the bridge tie condition during a track inspection on September 9, 1996, nor were exceptions to tie condition taken during Amtrak's twice-weekly walking inspections.

Operations Information

Both Amtrak and New Jersey Transit trains operate over this section of the Northeast Corridor, and all train traffic is governed by Northeast Operating Rules Advisory Committee (NORAC) Operating Rules, Fifth Edition, effective January 1, 1995. Operating Rule 261, Interlocking Rules 600 through 616, and Cab Signal System (CSS) Rules 550 through 561 were in effect at the time of the derailment. About 300 Amtrak and New Jersey Transit trains cross Portal Bridge each day.

Regulations regarding drawbridge operations are contained in 33 CFR Part 117, with Part 117.723 making specific reference to Portal Bridge. The regulation states that the bridge does not have to be opened Monday through Friday, except Federal holidays, from 7:20 a.m. to 9:20 a.m. and from 4:30 p.m. to 6:50 p.m. (morning and evening rush hours). At all other times, a requested opening may not be delayed by more than 10 minutes unless the bridge operator and the vessel operator, communicating by radiotelephone, agree to a longer delay.

Portal Bridge has no regularly scheduled openings. Requests for a bridge opening are conveyed by radiotelephone from a vessel on the river to the bridge operator. The bridge operator occupies the bridge control house, which is located at the center of the movable span about 22 feet above the tracks. The Portal Bridge operating log indicated that, between November 1995 and November 1996, the bridge was opened for river traffic or testing 303 times, with 31 operating failures reported.

In 1987, new trackwork and new electrical controls and power devices were installed on the bridge, a revised signal system was installed, and new operating rules were implemented regarding bridge operation. Since 1987, it has been necessary for the bridge operator to obtain permission from the Amtrak section "A" train dispatcher before opening or closing the bridge. Only the dispatcher, located in New York City, can unlock the bridge and make available the electric power needed to disconnect the bridge's electrical and structural elements and rotate the movable span.

Before the bridge can be opened, all signals governing train movement over the bridge must be at stop, and the track circuits within the limits of the interlocking must be unoccupied. If a signal other than stop is displayed over the bridge prior to opening, the dispatcher must request a stop signal and then wait a predetermined time before allowing the bridge to be opened.

The operation of Portal Bridge is described in the three-volume manual, *Portal Bridge Maintenance and Operation*, published in 1982 by Link Control, Inc., the manufacturer of the bridge electrical controls. Volume II, Section No. 3, of the manual, titled "Electrical Control and Operating Motor System," outlines the step-by-step procedure to be used when operating the bridge. According to the supervisor, prior to the accident, new bridge operators were given on-the-job training and were considered qualified if they could demonstrate successful operation of the bridge. They were not trained on the operating manual, nor were they required to be so trained.

Portal Bridge was designed to be operated in any of six operating modes: automatic opening, automatic closing, manual opening, manual closing, emergency opening, and emergency closing. Both automatic and manual operation are accomplished using controls at the bridge operator's control desk. Manual operation refers to using pushbuttons to individually control each component of the operating machinery. Emergency operation is accomplished through the use of hand cranks and should be employed, according to the operating manual, only in the event of component or system failure. Amtrak told the Safety Board that the automatic mode of operation was disabled after the miter rail detection/indication limit switches were removed in 1987.[12]

Portal Bridge operating devices, including the catenary skids, center and end wedges, miter rails, and centering devices are interconnected such that the actions necessary to either open or close the bridge must be taken in a predetermined sequence. The bridge operating manual states that "strict adherence to the operating sequence should be maintained, in order to insure successful operation." The "operating sequence" consists of a series of steps that must be taken to either open or close the bridge. In either automatic or manual mode, each of these steps must be successfully completed before the operation can progress to the next step. Indicator lights on the bridge operator's control desk show

[12]For more information on the removal of the rail position indication circuitry, see "Portal Bridge Miter Rail Configuration History" elsewhere in this report.

green or amber after each step to indicate whether or not that action was successful. If a light should indicate a failed operation, the bridge operator can use a bypass switch on the control desk to instruct the system to ignore the failure indication and continue with the next step in the operating sequence.

On February 11, 1987, Amtrak issued instructions to Portal Bridge operators and electricians that they were to physically inspect bridge components after a failure indication and before using a bypass switch. Amtrak officials told the Safety Board that, because of the removal later that year of the miter rail limit switches and thus the electrical circuit that was designed to detect the position of the miter rail, the control system displayed a failure indication after the miter rails were raised or lowered during any opening or closing operation. In order to carry out the operating sequence, bridge operators had to use the miter rail bypass switch. In 1987, use of the bypass switch became the standard operating practice. Operators were not required to physically inspect and confirm the position of the miter rails before using the bypass switch.

Meteorological Information

At 6:28 a.m., the approximate time of the derailment, the weather was clear, with an ambient temperature of 35°F.

Toxicological Information

In accordance with FRA requirements at 49 CFR Part 219, postaccident toxicological testing was conducted on the crew of train No. 12 (engineer, conductor, and assistant conductor), the train dispatcher, the Portal Bridge operator, the B&B electrician, and the C&S maintainer within about 9 hours of the accident. All results were negative for drugs and alcohol.

Tests and Research

Bridge Tests -- On November 24, 1996, Safety Board investigators observed a test bridge opening to determine how the miter rails would operate with broken side bars. The operator began the sequence to open the bridge in the manual mode. First, the catenary skids were lifted, then the center wedges were pulled. The next step was to pull the end wedges and raise the miter rails. As the miter rail and its attached running rail on the west end of the north rail of track 1 (the accident location) were being raised, the broken side bars allowed the miter rail to separate from the running rail at the rail joint. The running rail (with partial side bars still attached) then dropped back into the bed plates while the heel of the miter rail (also with partial side bars attached) continued to be raised to its fully elevated position. Meanwhile, the tapered end (toe) of the miter rail remained in the bed plate on the approach span, in contact with the tapered end of the stationary rail on the bridge approach. With the miter rail in this position, the center span of the bridge could not be rotated without damaging the tracks or other bridge components.

When the bridge operator lowered the miter rails, the broken side bars on the heel of the track 1 north rail miter bar came to rest on top of the broken side bars of the running rail, leaving the miter rail surface about 5 inches higher than the running rail. This position corresponded to the position in which the miter rail was found after the derailment.

Another test was conducted to determine if any other mechanical or electrical problems could be identified that would have kept the bridge from opening on the day of the accident. Investigators determined that, with the catenary skids raised, the center wedges pulled, the end wedges pulled, and (all) the miter rails raised, the bridge could be rotated counterclockwise without difficulty.

Signal Tests -- Safety Board investigators tested the signal circuits for the miter rails on track 1 on the west end of the bridge to determine if they complied with the requirements of 49 CFR Part 236.312. The regulations require that before a signal governing movement over a bridge can display an aspect to proceed, the rails on the movable span must be within 3/8 inch of the correct mating surface and in alignment with the rail seating device on the bridge abutment or fixed span. To carry out the test, investigators placed a 1/2-inch-thick obstruction on each rail seat and tested whether the normal indication circuit controller contacts remained opened. The tests revealed that a signal to proceed across the bridge could not be displayed with the track rail on the movable span more than 3/8 inch from the mating surface on the rail of the fixed span.

Bridge Event Recorder Information -- The Portal Bridge event recorder, located at MP 6.1, records the positions of relays that monitor the positions of various bridge operating devices. The event record for the period between 2:03 a.m. November 22, 1996, and 6:28 a.m. November 23, 1996, showed that the last successful bridge opening prior to the accident was at 2:03 a.m. on November 22, the day before the accident. The bridge was fully open from 2:07 a.m. until it began to close at 2:11 a.m. At 2:16 a.m., the bridge was fully closed, and the electrical power necessary to operate the bridge was removed by the Amtrak train dispatcher.

The next bridge opening attempt took place about 26 hours later, on November 23, 1996, at 4:03 a.m. The event recorder indicated that 310 trains had moved over the bridge since its last opening. According to the event recorder data, the bridge operating devices sequenced properly for an opening, but when the operator attempted to rotate the swing span, the bridge brakes cycled between release and apply modes, but the bridge span did not move. The bridge was electrically locked at 4:17 a.m. At 5:41 a.m., the event recorder indicated the manipulation of the brakes by the B&B electrician. At 5:50:32 a.m., the bridge was unlocked by the train dispatcher at the bridge operator's request. It was locked at 5:50:51 a.m. by the train dispatcher at the B&B electrician's request.

The recorder data indicated that the B&B electrician continued to test the brakes from 6:00 a.m. to 6:25 a.m. At 6:27:42 a.m., the track circuit on track 2 became deenergized (occupied by train No. 79), and at 6:27:47, the track circuit on track 1 became deenergized (occupied by train No. 12). At 6:27:56 a.m., the normal miter rail repeater relay for track 1 east deenergized.

Signal System Event Recorder Information -- The Portal Interlocking signal system event recorder records the position of relays monitoring signals, track, and various bridge operating devices. According to event recorder data, westbound train No. 79 entered the east limits of Portal Interlocking on track 2 at 6:27:28 a.m., operating under a clear signal. Eastbound train No. 12 entered the west limits of Portal Interlocking on track 1 at 6:27:32 a.m., operating under a clear signal.

Locomotive Event Recorder Information -- The three locomotives involved in the accident were all equipped with Bach-Simpson TMACS 100 event recorders. The recorders were designed to monitor and collect data on a number of locomotive operating parameters, including date, time, speed, distance, brake pipe pressure, traction motor current, direction of travel, dynamic and independent brake application, brake stand position, cab signal acknowledgment and alerter reset, and horn/strobe/bell usage. Event recorders from the three locomotives were removed under Safety Board supervision and delivered to Safety Board laboratories in Washington, D.C., where the data were downloaded and analyzed by Safety Board staff.

The TMACS 100 event recorder creates two data files: an event file and a crash file. The *event* file holds data reflecting any monitored activity that has taken place during the 2 days[13] preceding the time the recorder data are downloaded or the recorder is removed. The event file creates a record only when events occur; that is, when parameter values change. The *crash* file, on the other hand, comprises a second-by-second account of all monitored locomotive activity that has taken place in the 45 minutes prior to downloading the data or removing the event recorder. Safety Board staff used the crash file to interpret the event recorder data and provide a summary of each train's operations immediately prior to the accident.

Event recorder data from locomotive 910 (the lead locomotive of train No. 12) indicated that at recorder time 06:28:43 a.m.,[14] while train No. 12 was traveling at about 68 mph, the horn[15]

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[13]The time periods covered by both the event recorder (2 days) and crash recorder (45 minutes) are approximate. Actual data periods will vary.

[14]Recorder times are not synchronized from unit to unit, and they may not reflect exact actual time.

[15]The recorder's horn input monitors both horn and bell activity and does not distinguish between them. The "on" reading may indicate that the operator activated the bell, which causes the strobe light on the top of the locomotive to turn on as well, or that the operator sounded

sounded, and remained on for about 36 seconds. Approximately 32 seconds after the horn activity began, the brake pipe pressure decreased from 107 to 42 psi within a 1-second period.[16] During the following 1-second period, the brake pipe pressure dropped to 0 psi. About 3 seconds later, dynamic braking[17] was initiated. The independent brake[18] remained off throughout the length of the recording.

Data from locomotive 910 showed that, at recorder time 06:29:16 a.m., the train's speed—calculated from the number of wheel rotations—dropped from 56 to 45 mph within approximately 1 second. Based on Safety Board experience, such a deceleration rate would not be expected except in extreme circumstances, such as a head-on collision. Because the derailment of the train would have affected the ability of the event recorder to obtain an accurate count of wheel rotations, Safety Board laboratory analysts interpreted as invalid any speed recording between 06:29:16 a.m. and the time the recorded speed dropped to 0 mph at 06:29:22 a.m. Recorded data from locomotive 901 (the second unit on train No. 12) were consistent with data from locomotive 910.[19]

the horn, which activates the bell and the strobe. In this report, therefore, any mention of horn activity refers to the horn and/or the bell and strobe light.

[16]Train air brakes are applied in response to reductions in brake pipe pressure. In normal operations, the locomotive operator initiates the brake pipe pressure reduction, but a broken or disconnected train line will result in an automatic brake application.

[17]*Dynamic braking* is a method of train braking in which the locomotive's traction motors are converted to electric generators driven by kinetic energy from the moving train. The generated electricity flows into a resistor grid on the locomotive and is dissipated as heat. This electrical "load" on the traction motor/generator acts to slow the motor shaft rotation, resulting in a braking action being applied to the train wheels.

[18]*Independent brakes* affect the locomotive consist only and can be applied or released independently from the train brakes.

[19]After the accident, the event recorder from locomotive 901 remained submerged in salt water for about 48 hours. During the first attempt to retrieve the data, power could not be delivered to the recorder. The memory module was then removed and successfully downloaded using the recorder from locomotive 930.

Event recorder data from locomotive 930 (the only locomotive on train No. 79) showed that while train No. 79 was traveling at a speed of about 68 mph, the horn was activated and remained on until the end of the recorded data. About 20 to 22 seconds after horn activity began, the brake pipe pressure decreased from 108 to 81 psi, dropping to 0 psi in the following 2 seconds. The train came to rest at recorder time 06:26:42 a.m., about 48 seconds after the horn was activated.

Analysts found anomalies in the automatic brake stand settings[20] recorded for the lead locomotives of both trains. Crash data from locomotive 910 showed that the automatic brake stand setting changed from *in* to *out* for periods of 1 to 7 seconds throughout the data. Crash data from locomotive 930 showed that the setting changed from *in* to *out* intermittently about 12 to 14 seconds after the horn was turned on, and continued doing so until the end of the data. The *event* files, which record any changes in a monitored parameter, showed no changes to brake stand settings during the accident trip for either locomotive. Safety Board analysts consulted with Amtrak event recorder specialists and representatives of the manufacturer but were unable to resolve the discrepancy between the two data files.[21]

In accordance with the design of TMACS 100 event recorders, Safety Board laboratory analysts attempted to use traction motor current (TMC) readings to determine the activation,

[20]The automatic brake stand is the control station for the train air brake system. The brake stand control handle has three positions: *in* is the normal setting when the train is in operation and the train brakes are being controlled from that station; *out* is the normal setting at a nonoperating station, such as that in a trailing locomotive; *test* is the normal position when the train brake system is being tested for leaks, which usually occurs before a train leaves the yard. The automatic brake stand setting is usually placed in the *in* or *out* position before the train leaves the terminal and is not changed for the duration of the trip.

[21]Amtrak told the Safety Board that, at the time of the accident, it was in the process of upgrading its event recorders. Part of the upgrade was to eliminate the crash data record and change the event recorder update frequency to once per second. This upgrade was reported to have been completed for all AEM-7 Bach-Simpson event recorders in May 1997.

duration, and aspect (display) of any cab signals[22] during the accident sequence. These efforts were unsuccessful. (See "Other Information" section of this report for more detailed information.)

Metallurgical Information -- Six cracked or broken side bars were removed from Portal Bridge and examined in the Safety Board Materials Laboratory. For reference, the side bars were labeled "A" through "F." (As indicated on figure 7 – opposite.) Side bars A, B, C, and D were broken into two pieces. Bars A and B had been broken through at the time of the postaccident inspection; bars C and D were cracked when inspected after the derailment and broke as they were being removed from the assembly. Bars E and F were cracked but not broken through.

All the fractures and cracks were located near the beginning point of the notch where the width of the side bar changed from the full width along the miter rail to the reduced width (to accommodate the base flange) along the running rail. This was also the area where the bottom edge of the side bar transitioned from straight (along the miter rail) to beveled (along the running rail, to clear the base flange). The engineering drawings for the side bars showed the beginning of the notch as a straight cut resulting in a 90° transition. Side bars E and F displayed such a straight, right-angle cut, but the beginning point of the notches on bars A, B, C, and D had the appearance of a curved chamfer. Because of cracking and fracturing, investigators could not obtain an exact measurement of the radii of any of the notch transitions.

The drawings also indicated that the beveled notch should terminate 18 inches from the end of the bar. This location corresponds to the joint between the miter and running rails (and the end of the D bar) and is equidistant from the two nearest bolt holes. The notches of bars A, B, and C were 20 inches from the end of the bar, or about 2 inches past the rail joint. The notch of bar D was about 19 inches from the end, or about 1 inch past the rail joint. Measurements on bars E and F established that the notch ended at the specified 18 inches from the bar end.

The fractured areas of side bars A and B (taken from the location of the misaligned miter rail) were cut from the side bars and are shown in figure 8 (opposite). Amtrak told the Safety Board that cracks in both these side bars had been welded during trackwork performed during April and August 1996. Remnants of the repair welds were visible on the lower bar surfaces and in the countersunk portion of the bolt holes. Weld beads on the exposed faces of both bars appeared to have been smoothed with a grinder, slightly reducing the thickness of bar A at the fracture location.

Examination of the cross section of the fracture area revealed that the weld repair beads had fractured generally in the same plane as the previously existing cracks. The welds only penetrated 1/4 to 1/2 of the thickness of the bars and did not completely consume the existing cracks in the lower fracture segments. The fractured welds and surrounding surfaces displayed areas of porosity, slag inclusions, and lack of fusion in the weld fusion zone. In some areas on both bars, molten weld metal and slag had flowed onto the crack surfaces and solidified without fusing to the crack surfaces.

Dark discoloration at the weld fracture areas and in the remaining areas of the original fracture surfaces obscured the fine fracture features on the remaining areas of the original fracture surfaces. The visible, larger-scale features, including arrest lines, on both the upper and lower segments of both fractures were typical of fatigue crack progression. Ratchet marks at the lower edge of the fractures indicated that lower fracture segments of both the A and B bars initiated at multiple fatigue origins along the radius of the transition point for the notch.

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[22]The three locomotives involved in this accident were equipped with cab signals. Cab signals, located in the locomotive operating compartment, are a supplement to the standard trackside signaling system and display the signal—clear, approach medium, approach, and restricting (or stop)—in effect for the block in which the locomotive is operating. If a locomotive operator fails to acknowledge (by activating a switch) receipt of a cab signal that is more restrictive than the one under which the train has been operating, the train will automatically come to a stop.

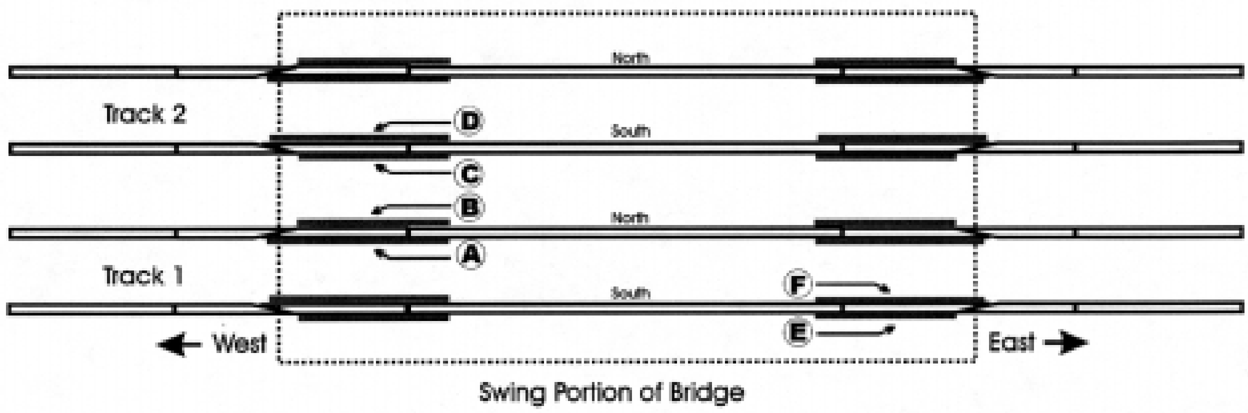

Figure 7 — Location and identification of the six side bars removed from Portal Bridge and examined in Safety Board laboratories

Figure 8 — Inner surfaces (with D bars attached) of the broken side bars removed from the accident location

On both bars, the fatigue propagated upward completely across the lower fracture segments, intersecting with the bolt holes. Fatigue zones were also apparent on the upper fracture segments of both bars. The upper segments of both bars showed evidence of weld repairs that partially consumed the preexisting fatigue zones.

Engineering drawings for the side bars called for the use of ASTM A36 steel.[23] In Safety Board tests, the side bar steel displayed a typical perlite ferrite microstructure consistent with the specified low-carbon structural steel.

Other Information

Portal Bridge Miter Rail Configuration History -- According to documentation provided by Amtrak, prior to 1985, the miter rails on Portal Bridge consisted of sections of regular running rail mitered at one end. The mitered ends of the mating rails were gapped to allow for expansion, but the gap resulted in battered rail ends. To correct this problem, Amtrak contracted with the Conley Frog/Switch & Forge Company to install Conley Expansion Rails, which were designed to provide a transition between the fixed and movable spans of a variety of drawbridge types. According to Conley literature, a device near the joint pulled down on the heel of the miter rails, which raised the opposite (tapered) ends to allow clearance for the bridge sections to move apart. A limit switch under the miter rail was part of rail position detection circuitry that provided electrical confirmation that the rail was down. Installation of the Conley rails on steel ties was completed in 1985.

Amtrak found that, because the toe ends of the Conley miter rails were not secured to the rail bed, the rail ends "bounced" when subjected to train traffic. The bouncing movement not only created vibrations in the bridge structure, it also forced the heels of the miter rails downward, which damaged the limit switches that detected rail position. Finding it uneconomical to maintain the repeatedly malfunctioning limit switches, Amtrak removed all the miter rail limit switches, and thus the rail position detection circuitry, in 1987, with the intent of replacing them with more durable components. Amtrak officials told the Safety Board that when the new limit switches arrived in 1988, the miter rail system was being redesigned, and the more durable limit switches were never installed.

In 1991, Amtrak began installing the high-speed miter rail system that was in place at the time of this accident. Installation of the new system, designed and built by Promex Company, Inc., was completed in 1992 and allowed train speeds across the bridge to be increased from 60 to 70 mph. According to an Amtrak official, the redesigned miter rail configuration required that the miter rail be joined with running rail using side bars because the steel used for the miter rail (at that time, SAE 4340) was not available in a billet longer than about 10 1/2 feet. Although the design of the system provided for the connection of circuitry to detect the position of the miter rail, the position detection circuitry was never installed. The absence of this circuitry required bridge operators to use bypass switches during any opening or closing of the bridge.

In 1993, the approach (stationary) miter rail on the west end of the north rail of track 2 cracked. Amtrak inspected the rail but could not determine the cause of the fracture. In 1994, the approach miter rail on the west end of the south rail of track 2 cracked completely through. Amtrak determined that a Promex employee or contractor had applied an oxyacetylene cutting torch to several bolt holes in the rail, weakening the rail in the hole area.

Two other swing bridges currently use the same Promex miter rail configuration as Portal Bridge: Spuyten Duyvil Bridge, located on Amtrak's Empire Connection and spanning the Harlem River in New York City; and Beach Bridge, located on New Jersey Transit's Atlantic City Line in Atlantic City, New Jersey. Both these bridges have miter rail position detection circuitry installed. An average of 18 trains traverse Spuyten Duyvil Bridge each weekday with a 30-mph speed limit for freight trains and a 45-mph limit for passenger trains. An average of 34 trains use Beach Bridge each weekday. A New Jersey Transit official told the Safety Board that the timetable speed for trains using Beach Bridge is 30 mph for passenger trains and 10 mph for freight, but that after the derailment at

[23]American Society for Testing and Materials, A36, "Standard Specification for Structural Steel."

Portal Bridge, a general order was issued implementing a restricted speed across the bridge.[24] Both Spuyten Duyvil and Beach bridges are low bridges that must open frequently to permit the passage of pleasure boats. Spuyten Duyvil Bridge is opened an average of 2,248 times per year; Beach Bridge is opened an average of 4,800 times per year.

New Jersey Transit officials told the Safety Board that, because of the cost of maintaining the Promex system, the agency is planning to replace the Promex miter rails with a miter rail system of Conrail design.

Previous Defects In and Problems With the Portal Bridge Miter Rail System -- In November 1995, Amtrak imposed a speed restriction on Portal Bridge track 2 after the side bars on the approach (fixed) miter rails were found to be cracked on the east end of the north rail. In December 1995, the approach span side bars were replaced with redesigned side bars.

The daily log of the Amtrak foreman of movable bridges indicated that on January 11, 1996, he went to Portal Bridge to replace a nut that a work crew on the bridge had discovered on the west end of the north rail of track 1. The log indicated that the loose bolt had backed out of its bolt hole and into a recessed bolt hole on the approach miter rail. When an attempt was made to lift the miter rail, the loose bolt prevented the rail from rising. With the tip of the rail jammed, the lift rod bent the rear part of the miter rail upward, elevating it slightly above the running rail. A passing train forced the rail back into position.

The movable bridges foreman's log indicated that, on January 22, 1996, he discovered that a nut was missing from a bolt on the spring lift rod assembly on the west end of track 1. The end of the bolt was mushroomed, so the foreman cut 1/4 inch off the bolt and replaced the nut. The next day, when the foreman returned to the bridge to put a lock nut on the spring rod assembly, he found bolts missing from the side bars on the west end of the north rail of track 1. After having the rails raised, he found that the remaining side bar bolts were loose. As he tightened the bolts, he noticed that the side bars were cracked. He stated that he immediately reported the conditions to the supervisor of structures, and that, the following day, January 24, 1996, he and the supervisor of structures returned to Portal Bridge where they inspected the other side bars for cracks. They reported finding cracks in the side bars on the west end of the south rail of track 2 and on the east end of the south rail of track 1.

On February 15, 1996, the Amtrak supervisor of structures sent a memorandum regarding the cracked side bars to the director of structures maintenance and the assistant division engineer for structures. The memorandum advised that three of the eight miter rail side bars on the west end of Portal Bridge were cracked at the bolt holes near the joint with the running rail. Photographs were enclosed with the memorandum. (See figure 9 – next page.)

On February 20, 1996, the director for engineering tests and standards received a copy of the February 15 memorandum. According to Amtrak, because the side bars, when fully seated, were cradled by the sides of the bed plate and therefore could not move, the cracked bars were considered a maintenance, rather than a safety, issue. The director for engineering tests and standards initiated plans to replace the side bars with bars made of a higher-strength steel. On February 27, 1996, an Amtrak employee from the Philadelphia office traveled to Portal Bridge to inspect the cracks on the side bars.

On March 5, 1996, the foreman of movable bridges escorted a representative of RN Utilities Sales, Inc., to Hunter Yard in Newark, New Jersey, where five spare manganese miter rails and three sets of A36 steel side bars were stored. RN Utilities Sales estimated that the side bars constructed of 4142 steel could be produced for $7,135 per set with a 3-week delivery time.

[24]Restricted speed under NORAC operating rules is 15 mph (or the timetable speed if that speed is lower). Train crews are required to be on the lookout for broken rails or other unsafe conditions and to be prepared to stop.

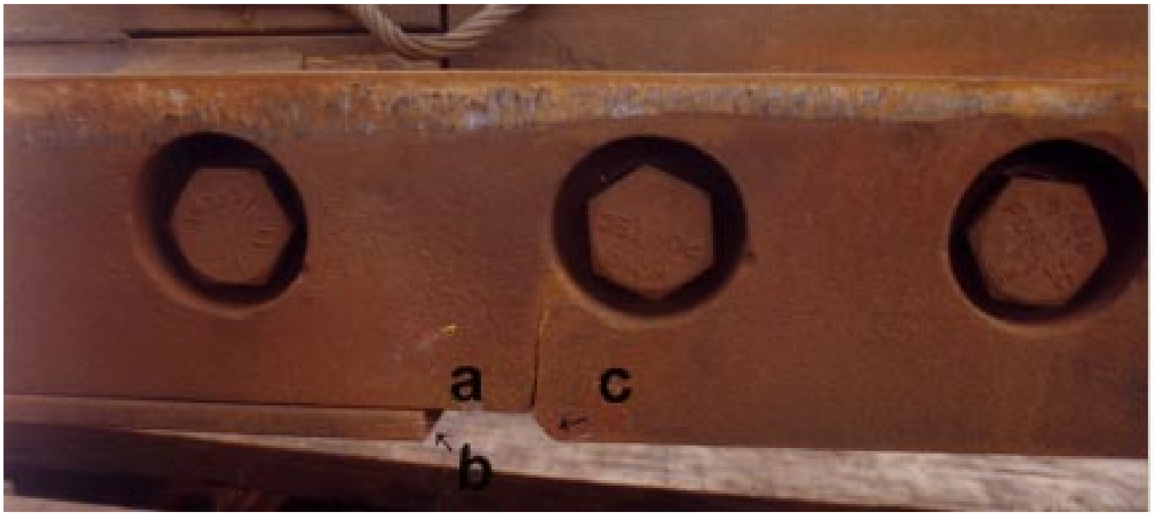

Figure 9 — One of the photographs of cracked Portal Bridge side bars sent in February 1996 by the Amtrak supervisor of structures to the director of structures maintenance and the assistant division engineer for structures. Note that the notch along the bottom edge of the side bar (a) extends beyond the end of the running flange (b), placing the transition to the notch (c) in proximity to a bolt hole.

On April 1, 1996, the movable bridges foreman went to Portal Bridge to replace five expansion rail bolts. While changing out the bolts and inspecting the bridge, he discovered that the side bars on the movable side of the bridge on the west end of the north rail of track 1 were cracked "all the way." On April 3, 1996, the director of engineering tests and standards sent a memorandum to the supervisor of structures with instructions to order 16 pairs of high-strength side bars.

On April 4, 1996, the director of structures maintenance, the director of engineering tests and standards, and the division engineer (who was also acting assistant chief engineer of the New York zone) met in Philadelphia with the assistant chief engineer for track to discuss the cracked miter rail side bars and a proposed plan for correcting the problem. This was the first time the division engineer was made aware of the cracked side bars on Portal Bridge.

The division engineer instructed the assistant division engineer for track to prepare to replace, that night, the entire miter rail assembly with a spare (preassembled) one from Hunter Yard. The supervisor of structures and the assistant division engineer for track were on site the night of April 4, 1996, when a track crew attempted to replace the miter rail assembly. According to Amtrak officials, the spare assembly could not be made to fit and was thought to be defective. Officials on the scene decided to reinstall the original miter rail assembly with its broken side bars. The supervisor of structures suggested that the broken side bars be welded, and the division engineer, the deputy division engineer (acting division engineer), the assistant division engineer for structures, and the assistant division engineer for track agreed to have the cracks welded as a temporary repair.

One week later, on April 13, 1996, an Amtrak welder was sent to weld the cracks in the side bars. The welder stated that he told his supervisor that a proper weld of the side bars would require removing them from the miter rail assembly so that the cracks could be welded

Amtrak's assistant chief engineer for track later told the Safety Board that welding was not an approved Amtrak repair method for these components.

In May 1996, the supervisor of structures ordered two sets of high-strength side bars from RN Utility Sales. On July 9, 1996, the first pair of high-strength side bars arrived at Hunter Yard; the second pair arrived on July 20. At the time of the accident on November 23, 1996, none of the replacement side bars had been installed.[25]

The electrical foreman's daily log indicated that, on August 29, 1996, one of the side bars on a rail on the west end of track 1 was "broke thru on one side," and the other side bar on that rail was cracked across 3/4 of its width. The log indicated that welding was to begin that night (August 29) at 10:00 p.m. The welder stated that, on August 29, 1996, he welded the side bars on the west end of track 1, using the same procedure he had used previously.

When Amtrak's assistant chief engineer for track was asked if a speed restriction had ever been put in place on Portal Bridge because of cracked or broken side bars, he said

> My personal judgment at that time was that a speed restriction was not required, but that the bars should be changed quickly, and that was the direction I gave to the division engineer at that time.

Amtrak Postaccident Actions -- Immediately after the accident, Amtrak issued a 45-mph speed restriction for Portal Bridge and placed a 24-hour watch on the bridge until all assistant chief engineers had inspected and approved it for train operations. The day after the accident, Amtrak crews began replacing the miter rail assemblies using material stored in Hunter Yard. The broken side bars were replaced (with the side bars that could not be made to fit on April 4). The work was completed on November 25, 1996.

On November 26, 1996, Amtrak issued a memorandum with the subject: "Movable Bridges." The memorandum read

> Until further notice, after any movable **BRIDGE** has been opened, and then closed, trains are not permitted to operate over the bridge until a visual inspection is performed by a qualified employee. These **INSTRUCTIONS MUST BE FOLLOWED** regardless of the status of the bridge lock indication received (i.e. miter rails seated, bridge lock indication received, etc.). [Emphasis in the original.]

The memorandum also specified which class of employees, B&B or C&S, was qualified to inspect and authorize train movements over each bridge.

On December 4, 1996, Amtrak issued a memorandum to Portal Bridge operators, subject: "Portal Bridge Inspection - Miter Rails." The memorandum read

> In the middle of each tour of duty, and at the change of your shifts on Portal Bridge, you are hereby instructed to inspect all four corners of the bridge for changes or deviations of any kind. If discrepancies are found they are to be reported immediately to the Trouble Desk in New York, and Section A. In addition, if there is an opening for marine traffic you are to physically inspect all eight rails to ensure they are properly seated, and in the proper position for railroad traffic. All inspections will be logged into the Movable Bridge Log Book, it is imperative we keep accurate records of these inspections.

On January 13, 1997, an Amtrak memorandum was distributed that read, in part, "Miter rail responsibility will be, as it should always have been, the responsibility of the Track Department."

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[25]Amtrak officials said they had planned to wait to make the side bar replacements until the following spring when the bridge was scheduled to undergo extensive work.

On January 27, 1997, Amtrak experienced another incident on the west end of the north rail of track 1, similar to the incident 1 year before (referenced earlier in this report) at the same location. The nut and washer had fallen off the second bolt from the toe of the movable miter rail. When that rail was down and mated to the toe of the stationary miter rail, the countersunk bolt holes on the tapered side of the movable miter rails were flush against the countersunk bolt holes on the tapered side of the stationary miter rail. The missing nut on the second bolt in the movable miter rail allowed that bolt to work out of the bolt hole far enough to penetrate the countersunk area in the adjacent miter rail, preventing the movable miter rail from being raised. When the bridge operator attempted to raise the obstructed miter rail, the force of the lifting rod on the heel of the rail caused the heel portion of the rail to bend upward.

According to radio transcripts, the C&S maintainer working out of the nearby work trailer saw the heel of the miter rail bend and notified the bridge operator, instructing him to lock the bridge and advising him that track 1 was "out of service." The bridge operator requested that the train dispatcher lock the bridge, but he did not tell the dispatcher that track 1 was out of service. With the bridge locked, the signal governing train movement over track 1 was set at clear to proceed.

A short time later, New Jersey Transit train No. 3820 approached the bridge, operating under the clear signal. The train's engineer applied the brakes to bring the train speed below the 45 mph temporary speed restriction across Portal Bridge. About this time, the train dispatcher, overhearing the C&S maintainer communicating with the bridge operator about the condition of the miter rail on track 1, changed the signal governing Portal Bridge to stop. The engineer stopped his train approximately 200 feet west of the Portal Interlocking signal.

As a result of this incident, on January 27, 1997, the Amtrak memorandum dated November 26, 1996, was amended to read that MW personnel were the only employees qualified to perform inspections and authorize train movements over Portal Bridge. Additionally, a 24-hour watch was instituted on the bridge to check the miter rails after every bridge opening to ensure that they were in place. Before this incident, Portal Bridge had last been jointly inspected by the C&S, B&B, and track departments on January 21, 1997.

On January 28, 1997, Amtrak issued a memorandum that read

> <u>Effective Immediately!</u>: We will have stationed at Portal Bridge, one (1) MW Foreman, whose responsibility will be as follows:
>
> 1. When any attempt is made by the Bridge Operator to activate the Bridge, whether or not the Bridge is open, each miter rail must be inspected Prior to any train movement to verify that it is safe for train movement and to verify that all miter rails have been seated properly.
>
> 2. While miter rails are in the up position, the foreman must check for loose bolts and take the appropriate action if required to ensure the safe passage of trains.

On January 30, 1997, Amtrak issued a memorandum to Portal Bridge operators and Spuyten Duyvil signal maintainers on the subject: "Movable Bridge Observation Procedures." The memorandum read

> Effective immediately, and without compromise to any former instruction(s), you will comply with the following for bridge operation:
>
> (1) Upon receiving a request for a bridge opening, you will visually observe all miter rails for… possible obstruction(s) to normal operation. This observation will be conducted at the track level.
>
> (2) With no exception taken with this observation, the bridge may be operated in accordance with standard operating procedures.
>
> The following corrective action will be immediately taken if any unusual vibration, unusual or loud noise, resistance to swing or any other refusal to properly operate occur: Place hold on track(s) immediately with respective dispatcher.

Supply appropriate information for taking this action. Make appropriate request(s) for assistance. Hold all trains clear of bridge until inspected (repaired) by qualified personnel. This procedure must be followed even when possible to display a signal over the bridge.

(3) Prior to returning the bridge and track(s) for train traffic, You will visually observe, for compliance, the following: (a) At track level, all miter rails for proper seating and alignment; (b) Proper control panel indication for rail seating, wedges fully driven and span locks in position.

(4) Document any exception taken, with regard to specific areas of concern, in the "comments" section of your respective operators log book.

During January and February 1997, the Amtrak signal department installed and activated proximity switches near the heel of the miter rails on all Amtrak swing bridges. The devices were wired in series with the circuit controllers (required by the FRA and already in place on the bridges) that monitored the position of the toe of the miter rail. With the additional components installed, a signal to proceed could not be displayed if either the toe or heel of a miter rail was positioned 3/8 inch or more from its mating surface.

On February 27, 1997, Amtrak issued a draft memorandum with instructions for the inspection and protection of miter rail assemblies. The new procedures, which were an addition to Amtrak's MW 1000 specifications for inspection and maintenance of track, were put in effect immediately. The final instructions were issued on March 6, 1997, and all employees assigned the duties of inspecting miter rail assemblies were trained in the new procedures. The bridge inspection training course consisted of 7 days of field and classroom training through the University of Wisconsin. In addition, a 1-week track inspection training course emphasizing "fix it," "slow order it," or "take it out of service" has been implemented.

In 1994, Amtrak began restructuring its engineering department and metropolitan division organizational structure. Amtrak officials stated that a major component of this reorganization was an effort to identify all areas within Amtrak engineering where additional standard plans, construction and maintenance procedures, and protection or protection design applications and policies were needed. Where these elements were lacking, they were to be developed, and employees were to be trained in their application.

Investigators learned that at the time of this accident a data base was being developed to automate the inspection tracking system. After the derailment, the process was "fast tracked" and in September 1997, field testing of the data base was underway. Additionally, an Amtrak audit team was reestablished in January 1997.

In February 1997, Amtrak, in consultation with experts on vibration and bridge design, undertook to redesign the miter rail system in use on Portal Bridge. The new design is being tested at Lehigh University prior to installation. The redesign will incorporate flash-butt welding of the miter rail in addition to the use of side bars.

Amtrak Locomotive Event Recorders -- Railroad locomotive safety standards[26] require that, as a minimum, locomotive event recorders be able to monitor and record the following parameters: train speed, direction of motion,[27] time, distance, throttle position, brake applications and operations (including train brake and dynamic brake applications and operations) and, where the locomotive is so equipped, cab signal aspect.

Throttle Position Recording -- Diesel-electric locomotives typically have a throttle control that is "notched" at several predefined throttle positions: dynamic braking, idle, and positions 1 through 8, all of which are monitored by the recording system. The electric locomotives involved in this accident were equipped with throttles that do not have predefined settings but

[26]Contained in 49 CFR 229.5(g).

[27]Amtrak provided the Safety Board with copies of an FRA document permanently waiving the requirement for Amtrak to monitor and record direction of motion in its trains. The TMACS 100 did, however, monitor this parameter.

instead can be positioned in varying increments anywhere within their operating ranges.

Amtrak provided the Safety Board with a March 31, 1994, letter from the FRA administrator to Amtrak's executive vice president providing guidance and instruction on issues related to event recorder regulation. The letter stated

> FRA's intention, expressed at 59 FR 36611, is that the recorder 'see' what the engineer sees (including cab signals) and record what the engineer does.

The letter further stated that

> FRA recognizes that in certain instances the intent of the rule may be satisfied either by recording events directly or by using a pre-determined and verifiable method to calculate or derive the required data from other data recorded directly. Where [ ] the latter approach is taken, the calculated or derived data should offer the same accuracy, reliability and precision as data recorded directly.

In particular, the letter addressed the issue of recording throttle position and/or TMC as follows:

> Traction motor current, dynamic braking current: The rule does not require the recording of traction motor current in either the power or the dynamic brake phase, although it is one way to provide the required recording of data on brake operations and equivalent throttle position or motoring mode.

Based on this guidance, Amtrak currently uses the recording of TMC in lieu of throttle position on all AEM-7 locomotives. According to Bach-Simpson, the manufacturer of the TMACS 100 event recorder, a high TMC value "generally" corresponds to a high throttle position, but the TMC and throttle inputs do not record identical information. While TMC typically ranges from 0 to 1,800 amperes (amps), a particular amperage does not necessarily correspond to a specific throttle position because grade and other track conditions can cause TMC to vary without a change in throttle setting.

Cab Signal Aspect Recording -- TMC is measured in amps. The TMC channel is multiplexed with cab signal aspect, meaning that the TMC input monitors both parameters. When the cab signal aspect changes, the recording of TMC is interrupted, and a record of the cab signal aspect and duration is made. According to the event recorder manufacturer, specific amperage values correspond to cab signal aspects, as follows:

Clear:	1,500 amps
Approach medium:	1,600 amps
Approach:	1,700 amps
Restricting:	1,800 amps

According to the manufacturer, these values are not precise, and the actual current may vary by about ± 20 amps. The length of the record for cab signal aspect is approximately 10 seconds.

On June 19, 1997, Amtrak's event recorder specialist notified Safety Board staff that in Amtrak's fleet of AEM-7 locomotives, including the three accident locomotives, the electric current module, a device that sends TMC data to the recording system, had been improperly configured at the time of the accident. The wrong TMC shunt had been used, with the result that the TMC value delivered by the current module to the event recorder was double the actual value. Because the event recorder does not record TMC values greater than 2,000 amps, any value of TMC that exceeded 1,000 amps (which was then doubled to 2,000 amps), was not recognized and stored properly by the event recorder. Thus, according to Amtrak, TMC data obtained from the three locomotives involved in this accident were invalid. According to Amtrak's event recorder specialist, Amtrak discovered the problem with the current module on December 16, 1996, and immediately began correcting the settings of the current module for all its AEM-7 locomotives. The specialist stated that the modules are currently configured properly for the full fleet.

Amtrak's event recorder specialist initially informed the Safety Board that cab signal aspect was recorded properly and was contained within the TMC data. When Safety Board analysts were unable to identify the cab signal aspect records throughout the event recorder data, they requested assistance from Amtrak. Amtrak then told the Safety Board that the problem with the current module settings that caused the TMC data to be anomalous also affected the cab signal data. According to Amtrak, cab signals had not been recorded, and it was therefore not possible to determine from event recorder data the cab signal that each train was operating under at the time of the accident.

A representative of an event recorder manufacturer told the Safety Board that the current module is not linked to cab signal aspect, and a problem with the current module should not cause the cab signal data to be erroneous. Although Amtrak has stated that the problem with the current module was corrected, an Amtrak representative said that the matter requires further investigation, because it is not clear whether cab signal data were recorded properly at the time of the accident.

According to Amtrak's event recorder specialist, TMC can reach values as high as 1,800 to 2,000 amps, which overlap the values assigned to specific cab signal aspects (1,500, 1,600, 1,700, and 1,800 amps). Safety Board analysts could not determine whether the value captured by the TMC input reflected the current drawn by the traction motor or the cab signal aspect. Nor could analysts determine with certainty the times at which the TMC signal may have been interrupted to create a record of a cab signal.

According to an event recorder manufacturer, an effective cab signal multiplexer design depends on the fact that locomotives do not normally operate at high traction motor currents, making the high values associated with cab signal aspect easy to distinguish from the rest of the data. The AEM-7 locomotives operated by Amtrak have high TMC values during normal operation, and analysts could identify no distinctive characteristic that could be used to mark the record of cab signal aspect. An Amtrak representative stated that the distinguishing feature of a cab signal record is its duration of 10 seconds, because under normal operation, TMC measurements are not constant for such a long period. The TMC data for locomotives 910, 901, and 930 showed several instances where the value was constant for longer than 10 seconds. None of the records in the TMC data were consistent with the values of cab signal aspects.[28]

Event Recorder Tests and Inspections -- Federal regulations require that locomotive event recorders be inspected every 92 days. Title 49 CFR 229.25(e) describes the tests to be performed during an inspection. The regulations require that,

> At a minimum, the event recorder test shall include cycling all required recording parameters and determining the full range of each parameter by reading out recorded data. A microprocessor-based event recorder equipped to perform self-tests has passed the pre-maintenance inspection requirement if it has not indicated a failure.

The event recorders installed on Amtrak locomotives 910, 901, and 930 were microprocessor-based, and were equipped to conduct self-tests. According to Bach-Simpson, the event recorder's self-test feature would not have detected the configuration problem that caused input current to be doubled as long as the TMC channel was not saturated.[29] The system cannot determine if the inputs are correct so long as they stay within the normal operating range.

Amtrak inspects each locomotive, including the event recorder, every 60 days. Locomotive 910 was inspected 17 days prior to the accident; locomotive 901 was inspected 46 days prior to the accident; and locomotive 930 was inspected 16 days prior to the accident. The 60-day inspections of all three locomotives did not identify any faults with the event recorder systems.

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[28]Amtrak has said that, with the completion of its upgrade of Bach-Simpson event recorders, cab signal aspect and TMC are now recorded on separate channels.

[29]The TMC channel is considered to be "saturated" if the input exceeds the predetermined maximum value of 2,040 amps.

Safety Board laboratory staff observed a 60-day test being performed at an Amtrak maintenance facility in April 1997. When inspecting the event recorder, Amtrak personnel first check the self-test feature and complete a checklist. They then attach a laptop computer to the event recorder and observe all parameters in real time. As operating conditions are simulated, each parameter is cycled through all possible positions while the data transmitted to the recorder are displayed on the computer screen. One page of the tabular event recorder data is included in the inspection records.

The examination that led to the discovery of the TMC configuration problem was not part of a periodic inspection but was an independent test of the TMC channel. The invalid TMC data were not noticed during periodic inspections. An Amtrak representative told the Safety Board that the problem was not detected earlier because TMC was not considered a significant parameter.

A representative of Bach-Simpson informed the Safety Board that testing of the system at the factory prior to delivery and procedural testing during installation should have ensured correct operation. He could not explain why the error went undetected. He said that installation drawings, instructions, manuals, and software are included with any new installation, and that when Amtrak installs and configures the recording devices and related equipment, Bach-Simpson representatives may be present.

Federal Oversight of Special Trackwork -- Special trackwork such as that found on Portal Bridge, as part of the “standard gage track in the general railroad system of transportation,” is subject to the FRA inspection standards contained in 49 CFR Part 213, “Track Safety Standards,” but such track is not normally included in FRA track inspections. FRA officials have told the Safety Board that track inspection standards have not been developed for special trackwork such as miter rail assemblies because these assemblies vary widely in their design and operation.

After this accident, the FRA initiated a program to inspect all movable bridges in the United States. According to FRA officials, 321 bridges were inspected as part of the program, which was completed December 31, 1996. The results of the survey were never distributed. Safety Board staffers requested a summary of the results and were told that a summary would not be produced. After several attempts, the Safety Board obtained from the FRA a copy of the completed survey.

FRA inspectors conducting the survey used a form to document, among other items, the proper seating and locking of bridge movable spans, and surface and alignment of movable and fixed rail sections. The inspectors also looked for cracks or breaks in the bars at the heels of miter rails and for mismatches of rail ends.

The survey contains about 600 pages of inspection reports and survey forms, supplemented by limited narrative information. Some defective conditions were noted, including cracks on miter rail castings, and FRA signal inspectors noted several bridges that did not comply with the requirements of 49 CFR Part 236.

ANALYSIS

General

The investigation determined that the crewmembers of trains No. 12 and No. 79 were qualified for their duties and that neither fatigue nor alcohol or other drug use was a factor in their performance during this accident. The weather was clear. Inspection and testing of the signal system indicated that the signal system functioned as designed, in accordance with FRA requirements, prior to the derailment. The Safety Board concludes that fatigue, drugs, weather, and the signal system were not causal or contributory factors in this accident.

The Accident

At 4:00 a.m. on November 23, 1996, the bridge operator on duty at Portal Bridge received a call from a marine vessel requesting that the bridge center be swung open to allow the vessel to proceed north up the Hackensack River. The bridge operator notified the Amtrak train dispatcher, who unlocked the bridge at 4:03 a.m. in preparation for the opening. The bridge operator testified that the first steps in the bridge opening sequence were completed normally. After he activated the switch to lift the miter rails, the operator did not receive a control panel indication that it was safe to proceed, because Amtrak had removed the rail position indication circuitry for the miter rails. In accordance with standard operating practice, the operator used a bypass switch to continue the bridge opening sequence. When he attempted to swing the bridge open, the swing span would not rotate. Feeling the bridge shake and vibrate, the operator aborted the opening.

The accident investigation determined that either prior to or during the attempt to lift the miter rail for the north rail on the west end of track 1, both side bars joining the miter rail to a longer running rail broke. As the lift rod pushed up on the miter rail, the miter rail and the running rail separated at the joint. The lift rod continued to lift the heel of the miter rail, but the toe of the rail remained seated in the bed plate for the stationary rail on the bridge approach span. When the bridge operator attempted to swing the movable span, the miter rail hung in the bed plate on the stationary span, preventing the bridge from opening.

When the bridge operator aborted the bridge opening, the lift rods lowered the miter rails, but the heel of the hung miter rail did not seat properly. Instead of falling back into the bed plate, it came to rest on top of the broken side bar sections attached to the running rail. The 5-inch difference in elevation between the two tracks created a ramp that would derail the next train to cross the bridge on track 1. The rail position detection circuitry that would have indicated on the bridge operator's control panel that the rail was not seated properly had been removed in 1987. Because electrical continuity was maintained across the rails despite the misalignment, the signals governing the Portal Interlocking displayed a clear indication. Amtrak procedures in effect at the time did not require that the bridge be physically inspected after a failed opening and before clearing the bridge for train traffic.

About 5:40 a.m., an Amtrak electrician arrived to troubleshoot the bridge and determine why it had failed to open. Although he walked onto the bridge from the well-lighted west end, he did not notice the misaligned rail. The electrician was still attempting to determine why the bridge had not opened properly when train No. 12 derailed on the bridge and sideswiped passing train No. 79.

In its investigation of this accident, the Safety Board identified two primary safety issues: Amtrak oversight of the inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge; and the effectiveness of Amtrak's emergency notification procedures. The Safety Board also examined the effectiveness of Amtrak locomotive event recorders in capturing critical operational data.

Design of Portal Bridge Miter Rail System

The miter rail assemblies in place on Portal Bridge at the time of this accident had been installed in 1992. A salient feature of the design was the joint between the miter rail and a section of running rail necessitated by the brittleness of the metal used for the miter rail. This joint was held together by side bars bolted onto each side of the two rails across the joint.

As lifting force was applied to the miter rails at a point about 25 1/4 inches from the joint, the rail's dead weight exerted tensile stresses along the bottom surface of the side bars and compression stresses along the top surface. Repeated lifting and lowering of the miter rails subjected the side bars to fatigue stress cycles. Fatigue stresses were increased by the presence of the beveled notch along the bottom edge of the side bars, which represented a major, stress-concentrating change in section on the tension side of the bars. In the area immediately on either side of the rail joint gap, all of the assembly's bending tension loads were carried by the side bars; none of this load was borne by either the miter or running rails.

These stress cycles resulted in 6 of 16 side bars on Portal Bridge sustaining fatigue cracks. All of the cracks originated at the transition point to the beveled notch where the design of the miter rail assembly tended to concentrate the forces (loads) when the rails were raised. Moreover, all the cracked and broken side bars taken from the west end of the bridge were improperly machined. The beveled notch on these side bars extended from 1 to 2 inches farther than necessary, which exaggerated the stress concentration by putting the change in side bar width closer to adjacent bolt holes. The bolt holes themselves were stress concentrators, and the material that was removed to create them further reduced the load-bearing cross section at that location. The change in side bar width and its proximity to the bolt holes on the improperly machined side bars may account for the earlier fracture of these side bars when compared to the correctly machined ones on the east end of the bridge. However, even the properly machined side bars showed evidence of fatigue cracks.

The fatigue cycles to which the side bars were subjected when they were lifted represented only a portion of the stresses the side bars were required to withstand. Added to this was the stress applied by the passage across the bridge of about 300 trains each day at an authorized speed of 70 mph. The extent and speed of the train traffic on Portal Bridge is in sharp contrast to the slower and much less frequent traffic across the other two bridges that use the Promex miter rail system. This difference in speed and number of trains each day likely accounts for any differences in reported side bar failures among the three bridges. The Safety Board concludes that the design, the materials, and the operation of the miter rail system in place on Portal Bridge at the time of this accident made the side bars susceptible to fatigue cracking and led to the side bar failure that precipitated this accident. The Safety Board believes that Amtrak should perform a comprehensive stress analysis of the design of any miter rail assembly currently in use or intended for use on Portal Bridge to identify critical areas of high cyclic stress. Amtrak should ensure that the miter rail design adequately accommodates these cyclic loads.

Maintenance of the Miter Rail System

Cracked side bars on the movable span of Portal Bridge were first documented in January 1996 when the foreman of movable bridges noticed cracks in the bars as he was replacing missing bolts at the west end of the north rail of track 1. He notified his supervisors, who arranged an inspection and took photographs of the cracked side bars. Amtrak's solution was to replace the bars with side bars constructed of higher-strength steel.

Eventually, new side bars of stronger material were ordered; in the meantime, however, Amtrak took no steps to repair the cracks, to slow trains crossing the bridge, to step up inspections of the miter rail assemblies, or to modify bridge operating procedures. Despite the critical function of the side bars, Amtrak officials did not consider the cracked side bars a safety issue since the rails and side bars were secured by the bed plate when in the seated position. They apparently did not consider that approximately once per day, the miter rails were raised to allow the bridge to open. Lifting the rails not only removed them from the security of the bed plate, it also subjected the side bars to the same stresses that had likely caused them to crack initially.

Only in April 1996, when the cracked side bars on the west end of the north rail of track 1 had broken completely through, did Amtrak undertake to replace the entire miter rail assembly. Unable to effect the replacement because the spare miter rail assembly could not be made to fit, Amtrak officials decided to weld the side bar cracks. Even then, however, the broken side bars were allowed to remain in place for a full week before a weld repair was attempted.

According to the Amtrak welder, he told his supervisor that the side bars could not be properly welded while they remained attached to the miter rail assembly, but he was told to weld them in place. Safety Board laboratory examination bore out the welder's concerns, revealing that the weld repairs were poorly carried out and should, at best, have only been considered a temporary fix.

The weld repairs were most likely made by shielded metal arc welding and, while this is an acceptable process for this material, the fact that the side bars were not removed for welding meant that the welds were partial joint penetration groove welds that extended only part of the way through the thickness of the bars and left residual fatigue cracks. According to the American Welding Society (AWS) code D1.1, section 2.5, Partial Joint Penetration Groove Weld,[30] "Partial joint penetration groove welds subject to tension normal to their longitudinal axis shall not be used where design criteria indicate cyclic loading could produce fatigue failure."

The *1995 Manual for Railway Engineering* goes further and expressly prohibits the use of partial joint penetration groove welds in steel bridge structures.[31] Evidence from one Amtrak official indicated that even Amtrak did not consider welding to be an approved repair method for the side bars, although several officials concurred in its use.

The weld repairs left the bars with significantly reduced cross-sectional areas, along with the remains of the cracks and the original notch ends, which acted as stress concentrators. The commentary on the *Structural Welding Code-Steel*[32] states, in part,

> A partial penetration groove weld has an unwelded portion at the root of the weld.… These unwelded portions constitute a stress raiser having significance when fatigue loads are applied transversely to the joint.

The side bars had obvious fatigue loads applied when opening and closing. The Safety Board therefore concludes that the welding that was performed on the side bars was inadequate and inappropriate as a permanent repair and served to concentrate stress on the already fractured areas of the side bars. The Safety Board further concludes that the weld repairs could have been adequate as a temporary fix had a detailed and repetitive inspection program been established to ensure continued safe operation until permanent repairs or replacements could be made.

In July 1996, the first set of new, higher-strength steel side bars was delivered, but Amtrak made no effort to replace any of the existing side bars, even those that had already broken through and had been welded. The Safety Board concludes that Amtrak management was aware of failures in miter rail side bars at least 10 months prior to the derailment, but because the company erroneously considered cracked or broken side bars to be a maintenance issue rather than a safety issue, it did not make replacements or permanent repairs that could have prevented this accident.

Inspection of the Miter Rail System

A review of periodic track inspection reports from September 2, 1996, through November 21,

[30] AWS Structural Welding Code-Steel, American National Standards Institute/AWS D1.1-86.

[31] Chapter 15, section 1.10.2 (e), reapproved with revisions in 1995.

[32] American National Standards Institute/AWS D1.1-86.

1996; monthly bridge inspections from January 19, 1993, through October 2, 1996; a Sperry Rail Track Geometry Report dated May 13, 1996; and the annual miter rail and expansion joint inspection on June 13, 1996, disclosed no defects in any of the side bars on any of the miter rails on Portal Bridge. On November 22, 1996, the day before the accident, an Amtrak track inspector made a walking inspection of the tracks on the bridge and reported finding no defects regarding the miter rails or their components.

The day after the accident, Safety Board investigators found that both side bars on three miter rail assemblies (six side bars total) were cracked. The Safety Board considers it unlikely that these cracks developed within a single day of the accident. More likely, the cracks had originated weeks or months before the accident and progressed slightly with each stress cycle. The Safety Board is concerned that repeated Amtrak inspections failed to reveal the presence of the cracks.

In the view of the Safety Board, Amtrak inspection procedures on Portal Bridge did not adequately address the special circumstances created by the Promex miter rail assemblies. The inspection procedures did not require that the miter rails be lifted to be inspected, even though the most critical components of the assembly were almost completely hidden when the rails were seated. At least as early as January 11, 1996, Amtrak became aware that a nut had fallen off a bolt in the toe of a miter rail, allowing the bolt to work out of its bolt hole and hang in the adjacent stationary miter rail. A short time later, on January 22, 1996, the movable bridges foreman found bolts missing from the side bars on the west end of the north rail of track 1. When he had the miter rails raised, he found that the remaining bolts were loose (it was also at this time that he noticed the cracked side bars). These nuts and bolts had obviously loosened gradually over time, but no inspection procedure had detected the problem before a potentially hazardous situation developed.

The loose or missing bolts and nuts in the miter rail assemblies should have prompted Amtrak management to amend its inspection procedures to include raising the miter rails for inspection to detect cracked or broken side bars, loose or missing track bolts, displaced track bolt heads, lifting arm mechanism cotter pins, etc. Experience with the amended procedures would have allowed Amtrak to determine an optimum inspection schedule that would have ensured miter rail integrity with the least adverse effect on train schedules. Instead, Amtrak management continued the inspection procedures that had proven to be completely ineffective in detecting problems with the miter rail assemblies. The Safety Board concludes that Amtrak management did not develop and implement miter rail inspection procedures that were adequate to identify defects in all components of the miter rail assemblies on Portal Bridge. The Safety Board further concludes that, had Amtrak, when it first learned about the cracked side bars on the miter rails, revised its miter rail inspection procedures to include raising the miter rails for inspection, the accident may have been prevented.

Only in January 1997, after the second incident in which a loose bolt jammed a miter rail and created a potentially hazardous situation, did Amtrak establish short-term procedures to ensure a thorough inspection of the miter rail assemblies while in the raised position. In March 1997, more than 1 year after problems with the miter rails had initially been detected, Amtrak issued new instructions for the inspection and protection of miter rail assemblies and established new training standards for inspectors. The Safety Board believes that Amtrak should continue to monitor the safety of special trackwork on its movable bridges and ensure that its special inspections are adequate and of sufficient frequency to detect failures or potential failures involving all components of all its special trackwork. The Safety Board further believes that Amtrak should develop and put procedures in place to ensure that any failures or potential failures that are noted during these inspections are corrected before they develop into safety hazards.

Removal of the Miter Rail Position Detection Circuits

Problems with excessive vibration on Portal Bridge began almost immediately after the installation of Conley miter rails on Portal Bridge in 1985. One result of the vibration was that the limit switches that had been installed to detect the position of the miter rails and to relay this information to the bridge operator's control panel failed repeatedly and could not be economically maintained. To correct this problem, Amtrak removed the limit switches and associated miter rail indication circuitry in 1987. Even though Amtrak purchased a new type of heavy duty circuit controller to replace the limit switches, the new devices were never installed on the Conley miter rails. When the Conley rails were replaced by miter rails of Promex design in 1992, no detection circuitry was installed, even though the mechanism had provisions for such devices.

The rail position detection circuitry served the important safety function of reporting to the bridge operator that the rails were properly lifted before an attempt was made to open the bridge and firmly seated again after the bridge was closed. In fact, the bridge interlocking mechanisms would not allow a bridge opening or closing operation to proceed unless (1) the system received a safe indication from the detection circuitry, or (2) the bridge operator used a bypass switch to allow the operation to continue without a safe indication. With no detection circuitry in place, bridge operators always used the bypass switch, even though, absent a visual inspection of the rails before and after each opening (which Amtrak did not require), the bridge operator had no way of knowing whether the attempt to raise or lower the miter rails had been successful. This explains why, on the morning of the accident, the bridge operator attempted to swing the bridge center span even while the toe of the miter rail on the west end of the north rail of track 1 was still seated in the bed plate on the approach span. The torque applied to the miter rail as the bridge span attempted to rotate may, in fact, have bent the rail slightly and contributed to the failure of the heel of the rail to align properly when the lift rods were retracted.

After he aborted the bridge opening, the bridge operator assumed that the rails were safe for train traffic because the signal system showed a clear indication. But the signal system indicated only that the rails made a complete electrical circuit and that the toe of the miter rail was positioned properly; the system could not and did not indicate that the heel of the miter rail was properly aligned.

If Amtrak management understood the important safety function served by the rail position detection circuitry, it did nothing to compensate for the removal of the system. An appropriate course may have been to require a visual inspection of the miter rails to confirm that they were completely lifted before opening and completely seated afterward. This practice could have been continued until the detection circuitry could be replaced. In a January 30, 1997, memorandum to Portal Bridge operators and Spuyten Duyvil Bridge signal maintainers, Amtrak instituted such visual inspections. The Safety Board is concerned, however, that for almost 10 years, Portal Bridge operators were allowed to assume that a critical procedure in the opening or closing of the bridge would always be successful and that no confirmation, electronic or visual, was required before using a bypass switch. The Safety Board concludes that if Amtrak management had had in place on Portal Bridge a functioning rail position detection system or procedures that required visual confirmation of the proper positioning of all miter rails, this accident probably would not have occurred. The Safety Board believes that Amtrak should ensure that current or future miter rail installations on Portal Bridge are equipped with a miter rail position detection/indication system that provides the maximum protection possible and that is interlocked with other bridge systems to prevent the bridge from being opened or cleared for train traffic until the position of the miter rails can be confirmed to be safe.

Emergency Response

Emergency response to the accident was delayed because of confusion about the accident location. The problem can be traced to the Amtrak police dispatcher who called the appropriate agency, the Secaucus Police Department, but relayed the accident location as "Portal Tunnel" instead of "Portal Bridge." The dispatcher further confused the issue when he called the North Bergen Police Department and reported the accident location as "Portal Tunnel Bridge."

Amtrak's computerized geographical data base indicated that the derailment fell within the Secaucus police area. The data base also provided the closest access roads. Even with the confusion about the specific accident site, the location of the two nearby roads should have provided enough information to allow either the Secaucus police or the North Bergen police to determine the most likely accident location. This did not occur, however. One reason may have been that the Secaucus police were apparently unaware that a Portal Bridge was located within their jurisdiction. It was only when a construction worker flagged down a Secaucus police cruiser that had been sent out to investigate and check known bridges in the area that the actual accident location became known.

As a result of this confusion about the accident location, the first ambulance did not arrive at the accident scene until 47 minutes after the initial notification. The Safety Board concludes that, had this accident resulted in more serious injuries, the confusing communication of the accident location by the Amtrak police dispatcher and the resulting delay in emergency response could have resulted in additional risks to train occupants. The Safety Board believes that Amtrak should review the training of its police dispatchers and ensure that dispatchers are trained to correctly identify all Amtrak locations to emergency response agencies.

Locomotive Event Recorders

Using Traction Motor Current to Indicate Throttle Position -- As shown by a 1994 letter from the FRA to Amtrak, the FRA considers the recording of TMC to be an acceptable method of monitoring throttle position on those locomotives, such as the AEM-7 locomotives involved in this accident, whose throttle controls do not have a finite number of predefined throttle positions. The Safety Board is concerned, however, that TMC data do not reflect the operator's actions, but only the response of the locomotive's traction motor to those actions. Depending on the circumstances, the traction motor will not always react the same way to a given throttle setting. While a high TMC value "generally" corresponds to a high throttle position and a low TMC value "generally" denotes a low throttle setting, the throttle position cannot be derived from TMC with reasonable accuracy, reliability, and precision because the response of the system depends on grade and other track conditions that vary continuously while the train is in operation.

Additionally, for the locomotives involved in this accident, the TMC data were invalid because of an improperly configured electric current module (a condition that was later found to be a fleet-wide problem with Amtrak's AEM-7 locomotives). However, even if the recording system had recorded TMC properly, the data would not have provided any information indicating the exact throttle settings used by the operator.

While TMC alone is a valuable operating parameter, knowledge of throttle position can be critical in the analysis of train handling. The Safety Board concludes that TMC data do not accurately indicate throttle position and, therefore, use of the data for this purpose by Amtrak does not meet FRA requirements for monitoring and recording train throttle position. The Safety Board believes that the FRA should inform the railroad industry that TMC is not a valid indicator of throttle position, and the requirement to record throttle position contained in 49 CFR 229.5(g) cannot be met by recording TMC. Additionally, the FRA should ensure that all operators currently using TMC as a substitute for throttle position modify their event recording systems to monitor and record throttle position directly.

Cab Signal Multiplexer and Current Module -- According to information provided by Bach-Simpson, the manufacturer of the event recorders installed on the accident locomotives, when a cab signal aspect changes, the TMC signal is interrupted, and a record of the cab signal is inserted in the data record. The signal activation and aspect are distinguishable within the recorded data by their high relative current levels. However, according to Amtrak, TMC values as high as 1,800 to 2,000 amps can be reached during normal operation of an AEM-7 locomotive. Thus, the range of TMC values overlaps the range of values assigned to specific cab signals, making it difficult, if not impossible, to determine whether the value depicted for the TMC channel reflects the current draw of the traction motor alone or the additional current draw that results from activation of a cab signal. For example, if the traction motor is operating at about 1,700 amps when the locomotive receives an approach cab signal (also 1,700 amps), the event recorder data provide no means of identifying the source of the current draw. Moreover, an approach signal will not always be recorded at 1,700 amps; the readings could be 1,684, 1,712, 1,690, or another value, making it even more difficult to identify cab signal data.

Amtrak initially informed the Safety Board that cab signal aspect was recorded properly for the accident locomotives, and that cab signal records were contained within the TMC data. After consultation with Safety Board staff, however, Amtrak agreed that cab signal indications were not recorded in a way that made it possible to determine the cab signal that each train was operating under at the time of the accident. As of August 1997, Amtrak was still not certain whether cab signal indications, a parameter the FRA requires to be monitored and recorded, is recorded properly on its locomotives. The Safety Board concludes that Amtrak's use of a multiplexer to monitor and record both TMC and cab signal on a single channel of the event recorder is inappropriate and ineffective and, as a result, Safety Board investigators found it impossible to determine cab signal indications in this accident. The Safety Board believes that Amtrak should perform a thorough test of the entire recording system on every locomotive equipped with an event recorder to ensure that cab signal data records can be easily and positively identified and evaluated.

Event Recorder Inspections -- Amtrak inspects each locomotive, including the event recorder, every 60 days, and each of the accident locomotives had been inspected and approved within 6 weeks of the accident. These inspections did not, however, identify the incorrect current module configuration that rendered invalid all recorded TMC information. Amtrak's event recorder specialist told the Safety Board that the problem was not detected earlier because TMC was not considered a significant parameter. In the view of the Safety Board, TMC *is* an important parameter, particularly since potentially critical cab signal data are recorded on the same channel. The Safety Board concludes that if the entire event recorder systems, including sensors, wiring, etc., in Amtrak locomotives 910, 901, and 930 had been thoroughly tested during their most recent 60-day inspections, the incorrect current module configuration would likely have been found and corrected, and the TMC data retrieved after this accident would have been useful in determining preaccident cab signals received by the traincrews.

It is important to note that the invalid data found during this investigation resulted from failed or inappropriately configured "sensors" and not from the actual event recorder units themselves. Most solid-state recorders have a self-test feature that can diagnose problems with the event recorder, but this feature does not test the validity of the data being provided to the unit. For example, a broken speed sensor might send the event recorder a speed of 0 mph. The recorder cannot detect whether the sensor is broken or the train simply is not moving, and the self-test does not extend to sensors or sending units. Currently, no testing or inspection is required for microprocessor-based self-testing recorders so long as the recorder indicates no faults during self-tests. Even for recorders that have no self-test feature, regulations do not require that the entire system be inspected, only the recording unit itself.

The issue of inadequate event recorder testing and inspection is not new to the Safety Board. As a result of its investigation of an accident involving the derailment of a freight train near Cajon Junction, California, in February 1996,[33] the Safety Board made four safety recommendations to the FRA regarding event recorders. One of those recommendations specifically addressed event recorder maintenance and inspection procedures:

> R-96-70
>
> Revise 49 *Code of Federal Regulations* 229.25(e)(2) to require that event recorders, including microprocessor-based event recorders that are equipped with a self-test function, be tested during the quarterly inspections of the

[33]Railroad Accident Report — *Derailment of Freight Train H-BALTI-31 Atchison, Topeka, and Santa Fe Railway Company near Cajon Junction, California, February 1, 1996* (NTSB/RAR-96/05).

> locomotive in such a manner that the entire event recording system, including sensors, transducers, and wiring, is evaluated. Such testing should include, at a minimum, a review of the data recorded during actual operation of the locomotive to verify parameter functionality as well as cycling all required recording parameters and determining the full range of each parameter by reading out recorded data.

In an August 15, 1997, letter to the Safety Board, the FRA stated that it had referred this recommendation to its Rail Safety Advisory Committee (RSAC). The letter stated that "the RSAC process will lead to expedited action" on the recommendation. The Safety Board will follow the progress on this recommendation closely. Based on the FRA letter, the Safety Board has classified Safety Recommendation R-96-70 "Open—Acceptable Response." At the same time, however, the Safety Board believes that additional FRA action is needed immediately. All three recorders involved in the Portal Bridge accident, as well as the one recorder involved in the Cajon Junction accident, were tested and found to be fully functional after the accident. The problems discovered with all four recorders were not related to the recording units themselves, but to the vital system components that send signals to the recording device. The self-test functions do not, nor are they intended to, detect failures in these components. The Safety Board therefore believes that, pending the results of the RSAC Event Recorder Working Group and the FRA's implementation of suitable requirements concerning event recorder system maintenance, the FRA should require that microprocessor-based event recorders equipped to perform self-tests be subject to the testing and inspection procedures currently applicable to all other types of event recorders. The Safety Board does not believe that the FRA should any longer consider a recorder to have passed the premaintenance inspection requirement based solely on the results of the self-test feature of a recorder.

Also pending the results of the RSAC event recorder working group and the FRA's implementation of suitable requirements concerning event recorder system maintenance, the Safety Board believes that the Association of American Railroads and the American Short Line Railroad Association should advise their member railroads of the need to test and inspect all microprocessor-based event recorders equipped to perform self-tests in accordance with those procedures outlined in 49 CFR 229.25(e)(2), which currently apply to all other types of recorders, to confirm proper event recorder function.

Amtrak Management Oversight of Safety Issues

The circumstances of this accident indicate that Amtrak's oversight policies may be lacking. Amtrak management did not take sufficient action to address the ineffectual inspection practices, delays in installing safety-critical miter rail assembly components, and unsuccessful repair procedures that preceded the Portal Bridge derailment.

Regarding inspection, Amtrak management did not adapt the inspection procedures on Portal Bridge to the special circumstances created by the Promex miter rail assemblies. The inspection procedures did not require that the miter rails be lifted to be inspected, even though the most critical components of the assembly were almost completely hidden when the rails were seated. Repeated incidents of personnel reporting loose or missing nuts and bolts in the assemblies did not prompt Amtrak management to make its normal inspection procedures more rigorous by requiring that the miter rails be raised during inspections. Not until March 1997, more than 1 year after problems with the miter rail side bars had first been detected, did Amtrak issue new instructions for the inspection of miter rail assemblies.

Amtrak management also did not effectively encourage prompt action in carrying out safety-critical maintenance. The cracked or broken side bars on Portal Bridge were discovered and reported to higher levels of Amtrak management at least 10 months before this accident, but satisfactory corrective action was not taken until after the derailment occurred. Also, although Amtrak management recognized the necessity of replacing the side bars, it did not direct personnel to make the replacements immediately. Even after replacement side bars were on hand, Amtrak management planned to delay installing the replacements until spring 1997, when other work was scheduled to be done on the bridge.

Finally, Amtrak management allowed the use of inadequate repair methods on the Portal Bridge miter rail assemblies. Amtrak management permitted temporary weld repairs that were contrary to Amtrak's own maintenance and repair guidelines to be used. In fact, the welder stated that even when he advised his supervisor that a proper weld of the side bars would require removing them from the miter rail, he was ordered to weld them in place.

These examples indicate that Amtrak management may not have emphasized safety as strongly as possible, at least with regard to the inspection, maintenance, and repair of the Portal Bridge miter rail assemblies. Therefore, the Safety Board concludes that Amtrak management failed to foster an environment that promoted adequate inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge and to permanently correct defects in the miter rail side bars that were discovered 10 months before the accident.

While this investigation found that those employees who carried out inspections and maintenance on the bridge followed Amtrak guidance, it also indicated that the guidance was not always appropriate and forceful. The circumstances of this accident, which could have had far greater consequences in terms of injury and loss of life, point out significant deficiencies in the Amtrak response to safety issues. The Safety Board therefore believes that Amtrak should conduct a comprehensive internal management review of the circumstances of this accident to determine why several layers of Amtrak management failed to act in a timely fashion to correct a known hazardous condition on Portal Bridge. The Safety Board further believes that Amtrak should make the management or procedural changes necessary to ensure that conditions affecting the safety of rail operations are given the highest priority.

Federal Oversight of Special Trackwork

Special trackwork such as that found on Portal Bridge, unlike virtually all other segments of track, is not routinely included in FRA track inspections and is therefore not subjected to the same FRA standards of maintenance and inspection as other track on the general railroad system. In the view of the Safety Board, such exception to the standards is not provided for in the FRA regulations promulgated in 49 CFR Part 213. Furthermore, this exception is totally inappropriate in that inadequately inspected and maintained special trackwork can have serious safety implications, as it did in this accident. The tracks leading up to Portal Bridge *were* held to FRA standards, and, while these Class 4 tracks accommodated about 300 trains per day operating at speeds approaching 70 mph, the special trackwork on the bridge was subjected to the same traffic. Yet, the condition and operation of this complex configuration of movable and stationary rails were virtually ignored by the FRA during its normal track inspections. The Safety Board concludes that if Amtrak had been required to meet Federal standards for inspection and maintenance of the special trackwork on Portal Bridge, the defects in the miter rail side bars may have been detected and repaired before they could cause a derailment. The Safety Board believes that the FRA should expand the scope of its track safety standards to include special trackwork such as movable miter rails and ensure that the condition and operation of special trackwork are included, when appropriate, in all FRA track inspections.

FRA Bridge Survey

Although the FRA inspected 321 movable bridges throughout the United States following the Portal Bridge accident, the agency did not distribute the survey results in complete or summary form. Based on its review of the survey, the Safety Board concludes that the results of the FRA movable bridge survey would be beneficial to the railroad and rail rapid transit industry in preventing accidents similar to the derailment on Portal Bridge. The Safety Board believes that the FRA should provide, in full or summary form, the results of its movable bridges survey to all railroads and rail rapid transit agencies.

FINDINGS

Conclusions

1. Fatigue, drugs, weather, and the signal system were not causal or contributory factors in this accident.

2. The design, the materials, and the operation of the miter rail system in place on Portal Bridge at the time of this accident made the side bars susceptible to fatigue cracking and led to the side bar failure that precipitated this accident.

3. The welding that was performed on the side bars was inadequate and inappropriate as a permanent repair and served to concentrate stress on the already fractured areas of the side bars.

4. The weld repairs could have been adequate as a temporary fix had a detailed and repetitive inspection program been established to ensure continued safe operation until permanent repairs or replacements could be made.

5. Amtrak management was aware of failures in miter rail side bars at least 10 months prior to the derailment, but because the company erroneously considered cracked or broken side bars to be a maintenance issue rather than a safety issue, it did not make replacements or permanent repairs that could have prevented this accident.

6. Amtrak management did not develop and implement miter rail inspection procedures that were adequate to identify defects in all components of the miter rail assemblies on Portal Bridge.

7. Had Amtrak, when it first learned about the cracked side bars on the miter rails, revised its miter rail inspection procedures to include raising the miter rails for inspection, the accident may have been prevented.

8. If Amtrak management had had in place on Portal Bridge a functioning rail position detection system or procedures that required visual confirmation of the proper positioning of all miter rails, this accident probably would not have occurred.

9. Had this accident resulted in more serious injuries, the confusing communication of the accident location by the Amtrak police dispatcher and the resulting delay in emergency response could have resulted in additional risks to train occupants.

10. Traction motor current data do not accurately indicate throttle position and, therefore, use of the data for this purpose by Amtrak does not meet Federal Railroad Administration requirements for monitoring and recording train throttle position.

11. Amtrak's use of a multiplexer to monitor and record both traction motor current and cab signal on a single channel of the event recorder is inappropriate and ineffective and, as a result, Safety Board investigators found it impossible to determine cab signal indications in this accident.

12. If the entire event recorder systems, including sensors, wiring, etc., in Amtrak locomotives 910, 901, and 930 had been thoroughly tested during their most recent 60-day inspections, the incorrect current module configuration would likely have been found and corrected, and the traction motor current data retrieved after this accident would have been useful in determining preaccident cab signals received by the traincrews.

13. Amtrak management failed to foster an environment that promoted adequate inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge and to permanently correct defects in the miter rail

side bars that were discovered 10 months before the accident.

14. If Amtrak had been required to meet Federal standards for inspection and maintenance of the special trackwork on Portal Bridge, the defects in the miter rail side bars may have been detected and repaired before they could cause a derailment.

15. The results of the Federal Railroad Administration movable bridge survey would be beneficial to the railroad and rail rapid transit industry in preventing accidents similar to the derailment on Portal Bridge.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of Amtrak management to foster an environment that promoted adequate inspection, maintenance, and repair of the miter rail assemblies on Portal Bridge and to permanently correct defects in the miter rail side bars that were discovered 10 months before the accident. Contributing to the accident were (1) the failure of the Federal Railroad Administration to develop track inspection standards for special trackwork and to periodically inspect such track as part of its oversight responsibilities and (2) Amtrak's removal of the miter rail position detection circuitry without installing replacement circuitry or implementing procedures to compensate for the loss of this safety-critical system.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations:

— to the National Railroad Passenger Corporation (Amtrak):

Perform a comprehensive stress analysis of the design of any miter rail assembly currently in use or intended for use on Portal Bridge to identify critical areas of high cyclic stress. Ensure that the miter rail design adequately accommodates these cyclic loads. (R-97-49)

Continue to monitor the safety of special trackwork on your movable bridges and ensure that your special inspections are adequate and of sufficient frequency to detect failures or potential failures involving all components of all your special trackwork. Develop and put procedures in place to ensure that any failures or potential failures that are noted during these inspections are corrected before they develop into safety hazards. (R-97-50)

Ensure that current or future miter rail installations on Portal Bridge are equipped with a miter rail position detection/indication system that provides the maximum protection possible and that is interlocked with other bridge systems to prevent the bridge from being opened or cleared for train traffic until the position of the miter rails can be confirmed to be safe. (R-97-51)

Review the training of your police dispatchers and ensure that dispatchers are trained to correctly identify all Amtrak locations to emergency response agencies. (R-97-52)

Perform a thorough test of the entire recording system on every locomotive equipped with an event recorder to ensure that cab signal data records can be easily and positively identified and evaluated. (R-97-53)

Conduct a comprehensive internal management review of the circumstances of this accident to determine why several layers of Amtrak management failed to act in a timely fashion to correct a known hazardous condition on Portal Bridge. Make the management or procedural changes necessary to ensure that conditions affecting the safety of rail operations are given the highest priority. (R-97-54)

— to the Federal Railroad Administration:

Inform the railroad industry that traction motor current is not a valid indicator of throttle position, and the requirement to record throttle position contained in 49 *Code of Federal Regulations* 229.5(g) cannot be met by recording traction motor current. Ensure that all operators currently using traction motor current as a substitute for throttle position modify their event recording systems to monitor and record throttle position directly. (R-97-55)

Pending the results of your Railroad Safety Advisory Committee Event Recorder Working Group and your implementation of suitable requirements concerning event recorder system maintenance, require that microprocessor-based event recorders equipped to perform self-tests be subject to the testing and inspection procedures currently applicable to all other types of event recorders. (R-97-56)

Expand the scope of your track safety standards to include special trackwork such as movable miter rails and ensure that the condition and operation of special trackwork are included, when appropriate, in all Federal Railroad

Administration track inspections. (R-97-57)

Provide, in full or summary form, the results of the Federal Railroad Administration movable bridges survey to all railroads and rail rapid transit agencies. (R-97-58)

— to the Association of American Railroads:

Pending the results of the Federal Railroad Administration (FRA) Railroad Safety Advisory Committee Event Recorder Working Group and the FRA's implementation of suitable requirements concerning event recorder system maintenance, advise your member railroads of the need to test and inspect all microprocessor-based event recorders equipped to perform self-tests in accordance with those procedures outlined in 49 *Code of Federal Regulations* 229.25(e)(2), which currently apply to all other types of recorders, to confirm proper event recorder function. (R-97-59)

— to the American Short Line Railroad Association:

Pending the results of the Federal Railroad Administration (FRA) Railroad Safety Advisory Committee Event Recorder Working Group and the FRA's implementation of suitable requirements concerning event recorder system maintenance, advise your member railroads of the need to test and inspect all microprocessor-based event recorders equipped to perform self-tests in accordance with those procedures outlined in 49 *Code of Federal Regulations* 229.25(e)(2), which currently apply to all other types of recorders, to confirm proper event recorder function. (R-97-60)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

December 18, 1997

APPENDIX — Investigation

The National Transportation Safety Board was notified at 8:30 a.m., eastern daylight time, on November 23, 1996, that National Railroad Passenger Corporation (Amtrak) passenger train No. 12 had derailed and sideswiped Amtrak passenger train No. 79 while traversing Portal Bridge in Secaucus, New Jersey. The investigator-in-charge and other members of the Safety Board investigative team were dispatched from the Washington, D.C., headquarters and the Atlanta, Georgia, regional offices. The investigative groups studied track and structures, signals and bridge operations, rail operations, mechanical factors, emergency response, locomotive event recorders, and metallurgy.

The Federal Railroad Administration, Amtrak, the Brotherhood of Locomotive Engineers, the United Transportation Union, the Brotherhood of Maintenance of Way Engineers, and Jersey City Emergency Medical Services assisted in the Safety Board investigation.

The Safety Board did not conduct a public hearing during this investigation.