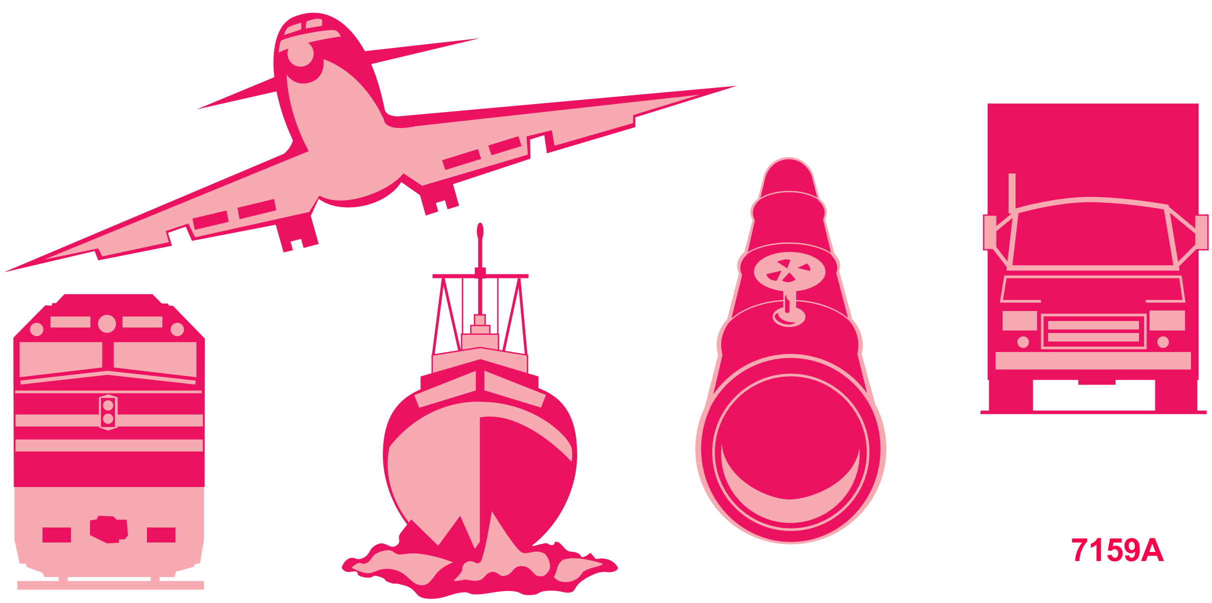
PB2001-916302
NTSB/RAR-01/02

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN 21 ON THE UNION PACIFIC RAILROAD AT ARLINGTON, TEXAS DECEMBER 20, 1998



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Railroad Accident Report

Derailment of Amtrak Train 21 on the Union Pacific Railroad at Arlington, Texas December 20, 1998

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Notation 7159A
Adopted July 24, 2001

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2001. ***Derailment of Amtrak Train 21 on the Union Pacific Railroad at Arlington, Texas.*** **Railroad Accident Report NTSB/RAR-01/02. Washington, DC.**

Abstract: About 7:00 p.m,. central standard time, on December 20, 1998, National Railroad Passenger Corporation train No. 21, the *Texas Eagle,* derailed on Union Pacific Railroad tracks in Arlington, Texas. Train 21 was en route from Chicago, Illinois, to San Antonio, Texas. The train was traveling westbound at a reduced speed of about 36 mph due to reports of rough track near milepost 231. Three locomotives and six cars derailed in a curve at milepost 230.62. Of the 198 passengers and 18 employees on the train, 12 passengers and 10 employees were injured. No fatalities resulted from the accident. The damages were estimated at about $1.4 million.

The safety issues identified in this report were the adequacy of the Union Pacific's procedures for responding to train crews' reports of track problems, the adequacy of the Union Pacific's oversight of track maintenance, and the adequacy of the Union Pacific's procedures for communicating changes in track classifications.

As a result of this accident investigation, the Safety Board made recommendations to the Federal Railroad Administration, the Association of American Railroads, the American Short Line and Regional Railroad Association, and the Union Pacific Railroad.

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Contents

Executive Summary

About 7:00 p.m., central standard time, on December 20, 1998, National Railroad Passenger Corporation (Amtrak) train No. 21, the *Texas Eagle*, derailed on Union Pacific Railroad (UP) tracks within the city limits of Arlington, Texas. Train 21 was en route from Chicago, Illinois, to San Antonio, Texas. The train was traveling westbound at a reduced speed of about 36 mph due to reports of rough track near milepost 231. Three locomotives and six cars derailed in a curve at milepost 230.62. Of the 198 passengers and 18 employees on the train, 12 passengers and 10 employees were injured. No fatalities resulted from the accident. Damages were estimated at about $1.4 million.

The National Transportation Safety Board determines that the probable cause of the December 20, 1998, derailment of Amtrak train No. 21 in Arlington, Texas, was (1) track conditions that were inadequate for the speed of the train, (2) the decision of the dispatcher to delay notifying track department personnel that a train crew had reported encountering rough track, (3) the inadequate effort on the part of the engineer of Amtrak train 22 to contact the dispatcher to report the observed track defect and its location, (4) the failure of the tamper operator to adequately resurface the track 4 days before the accident, (5) inadequate Union Pacific Railroad oversight of track maintenance work on this section of track, and (6) inadequate Union Pacific Railroad requirements for restricting train speed over track with reported rough conditions until track department personnel can assess track condition.

The safety issues identified in this report are:

- The adequacy of the UP’s procedures for responding to train crews’ reports of track problems;
- The adequacy of the UP’s oversight of track maintenance; and
- The adequacy of the UP’s procedures for communicating changes in track classifications.

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

Factual Information

Accident Synopsis

About 7:00 p.m., central standard time, on December 20, 1998, National Railroad Passenger Corporation (Amtrak) train No. 21, the *Texas Eagle*, derailed on Union Pacific Railroad (UP) tracks in Arlington, Texas. (See figure 1.) Train 21 was en route from Chicago, Illinois, to San Antonio, Texas. The train was traveling westbound at a reduced speed of about 36 mph due to reports of rough track near milepost (MP) 231. Three locomotives and six cars derailed in a curve at MP 230.62. Of the 198 passengers and 18 employees on the train, 12 passengers and 10 employees were injured. No fatalities resulted from the accident. The damages were estimated at about $1.4 million.

Preaccident Events

On the afternoon of December 20, a crew consisting of an engineer and a conductor was operating UP freight train ILBMN-18, with 2 locomotives and 36 cars, en route eastbound on UP track No. 1 from Fort Worth to Longview, Texas. The crew said that about 4:10 p.m., as the train went into a curve near MP 231 in Arlington, Texas, the ride become rough and the locomotive began to move up and down and side to side. They said they did not see anything wrong with the track, but the engineer said he became concerned that he may be traveling too fast for the conditions they were experiencing. (The UP had established a speed limit of 60 mph in the area for both freight and passenger trains.) Train ILBMN-18 successfully transited the area at about 56 mph. About 4:15 p.m., the engineer radioed the train dispatcher and reported encountering “rough track” at about MP 231.

About 4:00 p.m., on December 20, Amtrak train No. 22, with three locomotives and nine cars, departed Fort Worth eastbound on UP track No. 1 to Little Rock, Arkansas. According to the taped radio conversations, the train dispatcher radioed the crewmembers while the train was between stations Polly and Bowen, advising them to slow to 15 mph for a crossing at MP 229. The dispatcher told the crew that a freight train had reported rough track at MP 231 and that they should “be governed accordingly” when their train passed through that area.

The dispatcher had the authority to restrict speeds in an area of reported track problems, but he did not do so in this case. The dispatcher stated that if he had heard or known of a problem equivalent to a broken rail or signal problem, he would have required trains going over the area to travel at a restricted or walking speed (about 5 mph or less). The dispatcher said that he did not ask train 22 to verify the rough track and its location and that he did not hear from train 22 again. He also did not issue a track bulletin or contact maintenance personnel.

The dispatcher stated that he thought that he had done everything that the UP required him to do except tell a track inspector to look at the rough track. He stated that according to policy and his own experience, there is no time limit for calling a track maintenance person about a report of rough track. He stated that a call should be made on a timely basis and that he had fully intended to report the problem in the area of MP 231 to the maintenance-of-way department. He said he probably would have called the track department some time after 7:00 p.m., after trains 21 and 22 were through the area. He said that train 21 was a priority train that he wanted to get into the station before having someone look at the problem. He stated that, in his opinion, the warning from the freight train was not about a problem significant enough to warrant delaying trains so that the track could be inspected. The director of track maintenance stated that if the dispatcher had notified the local track maintenance department, they would have responded, “just like a fire truck,” as soon as possible.

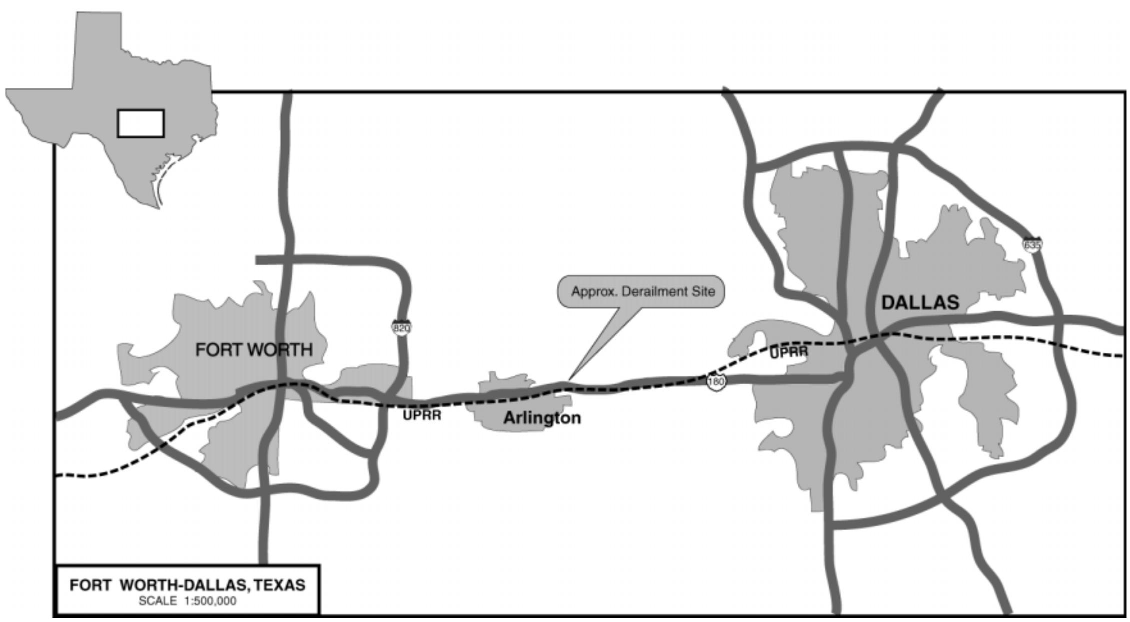

Figure 1. Accident location.

The train 22 crewmembers stated that they decided to transit the area at about 30 mph. They said they did not see or feel anything unusual as they passed MP 231, so they began to accelerate after passing the milepost. But about 0.4 mile past MP 231, near MP 230.6 (milepost numbers decrease in the eastbound direction), the crew said they noticed what looked like a “sun kink” in which the rail had moved outward and then back into line. The engineer described the kink as “dog-leg” shaped. He said he slowed the train to between 25 and 30 mph, and he felt lateral movement as the train successfully crossed over that section of track. The time was between 4:20 and 4:25 p.m. The engineer stated that the track in this area had “always been a little rough.”

After passing over the rough track, the engineer of train 22 tried, he said, to contact the dispatcher by radio to let him know that the defect was near MP 230.6, not MP 231 as had been reported. The engineer told Safety Board investigators that he tried for about 5 minutes, calling the dispatcher four to six times, as he traveled between MP 230 and MP 224. He was not able to reach the dispatcher. The engineer stated that in his attempts to reach the dispatcher, he did not use the tone 5 feature of the radio.[1] He said that once he came upon the defect detector[2] at MP 223, he abandoned his attempts to contact the dispatcher so that he could give his full attention to the defect detector. He said that he then forgot to contact the dispatcher and, therefore, never reported the proper location of the rough track.

The engineer also told Safety Board investigators that he had intended to tell the westbound Amtrak train 21 crewmembers about the kinked track near MP 230.6 when he met them at the station in Dallas. However, after arriving in Dallas (about 2 hours after having passed the track defect), he forgot to warn the crew of train 21.

The Accident

Train 21, with 3 locomotives and 10 cars, was operating westbound on UP track No. 1, en route to San Antonio from Chicago. For the segment of the trip between Little Rock and Fort Worth, the crew normally consisted of an engineer, an assistant engineer, a conductor, and an assistant conductor. Because of the possibility that the regular crew could not reach Fort Worth before it exceeded the 12-hour duty limit established by the Hours of Service Act (49 *Code of Federal Regulations* [CFR] Part 228), an engineer and a conductor boarded the train in Dallas to be available to relieve the regular crew if necessary. As the train traveled westbound from Dallas, the regular engineer, regular assistant engineer, and relief engineer were in the cab of the lead locomotive.

The engineer said that the dispatcher had warned him about rough track being reported near MP 231, and he planned to go through the area at about 30 mph instead of the normally authorized speed of 60 mph. He said he had noted no track deficiencies approaching MP 231, but as he neared the site, at about 7:00 p.m., his train dropped off the tracks and derailed in a curve. According to event recorder data, and consistent with engineer statements and communications and signal data, the train was moving about 36 mph when the derailment occurred. (See figure 2.)

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[1] See “Radio Communications” section below for more information.

[2] Wayside *defect detectors* typically broadcast information about the train to the operating crew by radio. Depending on design, defect detectors can identify “hot boxes” (overheating journal bearings), dragging equipment, or overheated wheels (usually caused by sticking brakes).

Emergency Response

The accident site was within the city of Arlington, and the Arlington Fire Department was the initial and principal responding municipal fire and rescue agency. Additional support was provided by the Arlington Police Department and contracted municipal ambulance services.

At 7:02 p.m. (2 minutes after the accident), an unknown caller told the Arlington emergency (911) operator about the derailed train. The caller told the operator that the location of the accident was the railroad tracks east of Stadium Drive, in the 2000-to-2100 block of East Division Street; numerous additional calls followed to report the accident. The Arlington Fire Department responded with 13 engine companies (pumping trucks), 1 aerial platform truck, 3 truck companies, and 2 additional support/utility vehicles.

Approximately 60 firefighters (some with training as emergency medical or paramedical technicians) and two battalion chiefs went to the scene, along with several administrative support employees. In addition, 25 workers with training as emergency medical or paramedical technicians (including supervisory and operations employees) and 15 reserve disaster workers responded during the evacuation and rescue of passengers. A total of 17 people were transported to hospitals by 11 ambulances from municipal services.

According to the Arlington Fire Department battalion chief, when the firefighters crossed the drainage ditch with rescued train occupants, they had to maneuver through passenger cars that were lying on their sides. None of the people on board the train had been trapped in the wreckage. Passengers in cars that were essentially upright were able to

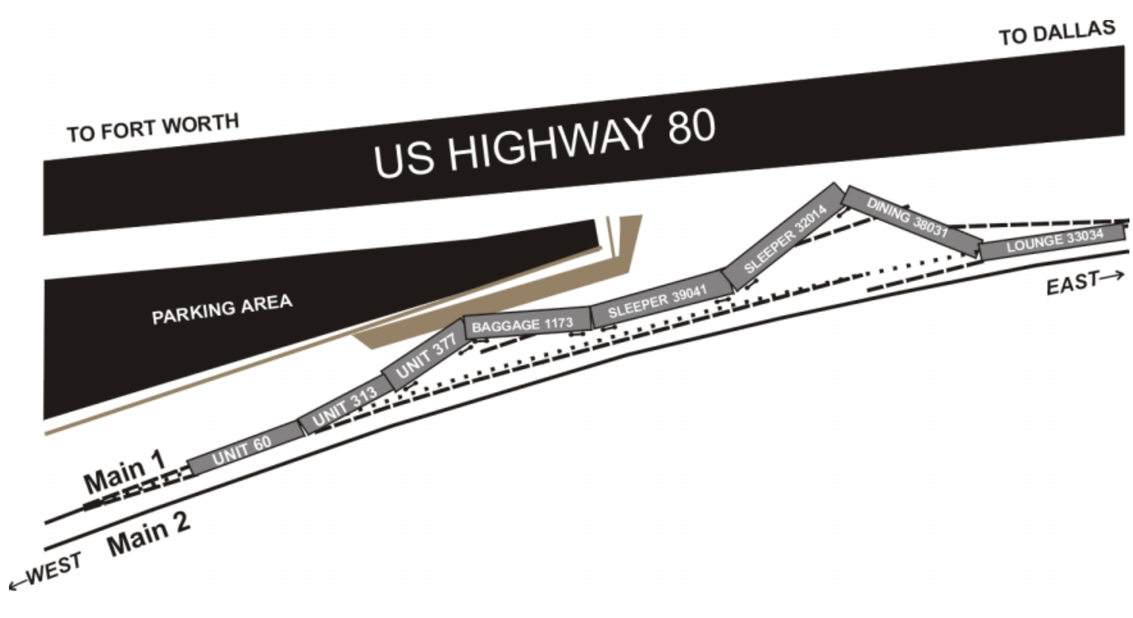

Figure 2. Accident scene. Units 60, 313, and 377 are the locomotives of Amtrak train No. 21.

leave immediately and directly through open passageways and doors. In cars that were not upright, some passengers were unable to leave directly through open passageways (open doors or emergency windows) and were extricated by means of ladders, which firefighters put through opened emergency exit windows.

Injuries

Table 1 is based on the injury criteria defined in 49 CFR 830.2,[3] which the Safety Board uses in accident reports for all transportation modes. The data is compiled from medical records of those people who were injured in this incident and treated by area hospitals within 24 hours of the accident.

Table 1. Injuries

Injury Type	Amtrak Crewmembers	Amtrak Passengers	Total
Fatal	0	0	0
Serious	0	0	0
Minor	10	12	22
None	8	186	194
Total	18	198	216

Damage

The UP and Amtrak provided the following damage estimate:

Equipment	$ 1,354,400
Track	$ 55,000
Total	**$ 1,409,400**

[3] Title 49 CFR 830.2 defines fatal injury as “any injury which results in death within 30 days of the accident” and serious injury as “an injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface.”

Train 21 Damage

All 3 locomotives and 6 of the 10 cars of Amtrak train 21 derailed. The lead and second locomotives remained upright and aligned with the track. The third locomotive and the first four cars turned at different angles to the track and fell on their sides to the north side of the track, at the edge of a drainage ditch just 15 to 20 feet south of U.S. Highway 180. The fuel tank of the third locomotive ruptured, spilling approximately 600 gallons of fuel onto the ground. The fifth and sixth cars derailed but remained upright and essentially aligned with the track. The remaining four cars did not derail and were not damaged.

Track Damage

About 550 feet of No. 1 main track was destroyed.

Personnel Information

Train 21

Amtrak records indicate that the assigned engineer had been issued an engineer's certificate on July 16, 1997, with an expiration date of July 16, 2000. His most recent test on operating rules before the accident was on March 2, 1998. On April 29, 1997, he had successfully passed a re-certification class that covered equipment inspection, train handling, personal safety, and air brakes. His most recent over-the-road evaluation by a supervisor before the accident was on December 18, 1998, 2 days before the accident. He completed instructor engineer orientation on November 23, 1997. None of his records indicated any disciplinary actions.

Amtrak records indicate that the assistant engineer had been issued an engineer's certificate on February 6, 1997, with an expiration date of February 6, 2000. His most recent test on operating rules before the accident was on November 2, 1998. On December 9, 1996, he successfully passed a re-certification class that covered equipment inspection, train handling, personal safety, and air brakes. His most recent over-the-road evaluation by a supervisor before the accident had been on December 18, 1998. None of his records indicated any disciplinary actions.

Train 22

Amtrak records indicate the engineer was issued an engineer's certificate on July 16, 1997, with an expiration date of July 16, 2000. He had most recently been tested on the operating rules on November 3, 1998. He successfully passed a re-certification class that covered equipment inspection, train handling, personal safety, and air brakes on April 28, 1997. His most recent over-the-road evaluation before the accident was on November 29, 1998. He completed instructor engineer orientation on November 23, 1997. He had no record of any disciplinary actions.

Dispatcher

The dispatcher had worked as a UP dispatcher for 3 1/2 years. On the day of the accident, he was working the second shift (3:00 to 11:00 p.m.). His regular days off were Monday and Tuesday. He had completed an orientation course at the UP's Harriman Dispatch Center on April 14, 1995. In February 1996, he had participated in interactive training in improving the safety of working conditions for dispatchers. In February 1997, he completed training on rules pertaining to alertness and attentiveness around railroad tracks. The dispatcher's most recent annual rules examination was on November 25, 1997; he received a passing score. UP records disclosed no disciplinary information pertaining to the dispatcher.

Tamper Operator

The tamper operator (who had performed work on the track as described in the "Track History and Maintenance" section below) had been employed by the UP for 25 years. His job title was "machine operator." He had successfully completed a 2-week training program covering safety and the proper operation of the machinery.

Track Inspector

The track inspector/supervisor (who had inspected the track as discussed in the "Track History and Maintenance" section below) had been a railroad employee for 35 years, having begun with the Missouri, Kansas, and Texas Railroad in 1963. Before becoming a track supervisor, he had worked as an assistant road foreman. He had worked in Texas since 1974 and in Arlington since 1990.

Train and Mechanical Information

Train No. 21, the *Texas Eagle*, originated in Chicago on December 19. In Chicago, about 4:55 p.m., the train received an initial terminal air-brake test and an equipment inspection. The train departed Chicago on time, at 5:55 p.m.

After the train arrived in St. Louis, Missouri, the crew was changed and the four cars at the rear of the train were removed and replaced by six express[4] cars, including a two-way end-of-train device. The 19-car train then passed an intermediate air-brake inspection and test at 1:35 a.m. on December 20. Postaccident document reviews of the initial terminal tests in Chicago and the intermediate 1,000-mile air-brake test and equipment inspection in St. Louis revealed no reported exceptions or failures. No equipment problems were noted or reported by any of the train's engineers on the Amtrak MAP 100 Form ("Engineer's Equipment Problem Report") or to any dispatcher.

[4] *Express cars* are specially constructed cars added to passenger trains and used to transport express shipments; they are sometimes combined with facilities for handling baggage or mail.

Safety Board investigators inspected all equipment the day after the accident. They did functional single-car air-brake tests on passenger cars not damaged to an extent that would preclude meaningful and accurate testing. They measured and recorded the wheel-flange height and thickness of each wheel on the locomotives and derailed cars. They recorded back-to-back measurements for each locomotive wheel. They also inspected the truck components on all cars. All of the inspections and measurements indicated that the equipment was within specifications and without defects.

On December 22, 1998, at the UP locomotive shop in Fort Worth, the running gear of the lead locomotive unit was inspected as each of the four traction motors was removed. The circumference of each wheel was measured and recorded. Safety Board investigators also examined locomotive and car mechanical records and maintenance documents for clues to preexisting problems or conditions. The records did not indicate any anomalies.

Track Information

Description of Track

The derailment occurred on the UP Dallas subdivision of the Forth Worth Service Unit on the No. 1 main track at MP 230.62. This location is within the city limits of Arlington. No. 1 main track is the most northern of four parallel tracks. The remaining tracks are designated No. 2 main track, No. 1 yard (drill) track, and No. 2 yard track. A General Motors facility borders the tracks to the south, and Division Street (Highway 180) is about 60 feet north of No. 1 main track.

All four track structures are owned, inspected, and maintained by the UP. Both No. 1 and No. 2 main tracks carry traffic in both directions. In 1997, about 23 freight trains a day and 2 passenger trains 4 days per week accounted for an annual tonnage of about 15.08 million gross tons in the westward direction and about 11.96 million gross tons in the eastward direction.[5] The UP director of track maintenance stated that most of the train traffic was on No. 1 main track.

When westbound train 21 derailed, it was in a left-hand curve between MP 230.6 and 230.9. According to both the curve chart and the track profile, the section of track was designated as a 2-degree 5-minute curve. As class 4 track, the track was supposed to have a super-elevation (the difference in rail height between the outside and inside rails through the curve) of 3.25 inches.

When Safety Board investigators arrived on scene, UP track maintenance personnel were in the process of repairing the damaged track segment and had already removed about 550 feet of track, including the track at and adjacent to the point of derailment. Investigators could thus observe and measure only the track on either side of

[5] Latest data available.

the removed section and could make no inspection of track at the actual point of derailment.

The track structure in the area of the point of derailment was built on about 6 feet of fill.[6] The UP manager of track maintenance stated that the fill consisted primarily of native soil. The track segment was supported with granite ballast that was approximately 14 inches deep under the crossties and about 8 inches wide at the shoulder. The cribs (the spaces between the crossties) were not completely filled with ballast in the area adjacent to and under the rail, but they were full in the center of the tie area. During postaccident reconstruction of the damaged track, 27 to 30 carloads (2,500 tons) of track ballast were placed, resulting in an additional 12 inches of ballast beneath the crossties in the reconstruction area.

According to UP records, the rail was originally laid in 128-foot lengths. The UP identified this rail length as continuous welded rail. The manufacturer's stamping identified the rail sections as 115-pound rail that was manufactured in 1953, 1956, and 1957. The rail lay on wooden crossties that were, on the average, 19.5 inches apart. The double-shoulder tie plates were 8 inches wide and 13 inches long. The spiking pattern had five 6-inch cut track spikes per tie plate, with two spikes on the field side and three on the gage side. In 1994, according to track maintenance records, approximately 915 new crossties were installed on No. 1 main track between MP 230.0 and 231.0. The rail was box anchored[7] at every other crosstie by rail anchors.[8] The rail anchors appeared to be tight against the sides of the crossties.

Under the classification system established by the Federal Railroad Administration (FRA), track is classified according to the strength of the railroad structure (roadbed, sub-ballast, track ballast, crossties, tie plates, and rail), the track geometry (such as: cross-level,[9] super-elevation, gage,[10] alignment,[11] and clearance), and the maintenance schedule for the track. Higher track classifications translate to higher authorized train speeds. For example, the maximum speed allowed by the FRA on class 3 track is 60 mph for passenger trains and 40 mph for freight trains; the maximum speed on class 4 track is 80 mph for passenger trains and 60 mph for freight trains. In late October 1998, the UP had designated the track where this derailment occurred as class 4 track, but had limited passenger train speeds to 60 mph, the same as for its freight trains.

[6] The fill was measured from the ditch line to the top of the subgrade.

[7] Box anchoring places rail anchors on both rails across from each other on each side and against the side of a tie.

[8] Rail anchors are designed to transfer the longitudinal forces developed in the rail to the ties and ballast.

[9] *Cross-level* is the comparison of the height of the top of one rail when referenced to the opposite rail at the same location. In general terms, the cross-level of a section of tangent track should be zero, the cross level of curved track will indicate that the outer rail is higher than the inner rail. The outside rail of a curve should never be lower than the inside rail.

[10] *Gage* refers to the distance between each parallel rail of the track as measured between the inside heads of the rails at 5/8 inch below the top of the rail. The standard gage of track as used in the United States, Canada, Mexico, most of Europe, and parts of Asia and Africa is 4.708 feet (56 1/2 inches).

[11] *Alignment* refers to the maintaining or adherence of distance between rails (gage) to the centerline of the rails at individual locations in the rails in curves or along straight sections of track.

Track History and Maintenance

The UP director of track maintenance and two managers of track maintenance said that the accident area was a high-maintenance area in which it was difficult to maintain the proper track surface profile,[12] cross-level, and alignment. They said the problems seemed to be worse during rainy weather. They said the UP practice had been to make repairs and add ballast as needed. The regular UP track inspector said he did not consider that section of track problematic and did not look at this area more closely than any other.

Safety Board staff reviewed the UP daily track inspection reports for February 2 through December 18, 1998. According to those records, No. 1 main track was inspected twice weekly at intervals of not less than 24 hours, as required for class 4 track by 49 CFR 213.233. The records also indicated that the UP had taken corrective action when track defects were noted.

About 6 months before the accident, on July 13, 1998, the UP conducted a track geometry inspection with its EC-2 test car. At that time, the track was classified as class 3. According to the inspection records, the UP tested the track and found no exceptions under class 3 standards.

The last internal rail inspection on the No. 1 track before the accident was on July 28, 1998. The UP did the inspection with a DC-10[13] car. No rail defects were found between MP 207.25 and 231.25. The UP's summary report of test-car results on the No. 1 track during 1994, 1995, 1996, and 1997 reported only one defect, in 1994.

According to the UP, track and signal work necessary to upgrade the main No. 1 track from class 3 to class 4 was done before the end of October 1998. The track had been resurfaced, and the super-elevation had been increased from 1.25 inches to 3.5 inches. (The managers of track maintenance stated that the track may have been resurfaced one other time after November 1; however, the UP did not have a record of the work.)

On October 25, 1998, the UP redesignated the track as class 4. Beginning on November 1, the UP raised the speed limit (then 40 mph) by 5 mph each week until the limit reached 60 mph, which was the speed limit the company imposed on both freight and passenger trains using this track. The UP was not required to notify FRA headquarters of the reclassification.

An FRA track inspection, using a T-10 car,[14] took place on November 18, 1998. According to the FRA inspector, the track was inspected using standards for class 3

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[12] In railroad terms, *surface* refers to the vertical alignment of the rails with respect to one another. An imaginary plane can be formed on the top surface of railroad rails. This plane should be level for straight track and have the proper angle of elevation for curved track. Defects in track surface can result in one or both rails being below, or above, the intended height.

[13] The DC-10 is the UP's ultrasonic-equipped test car for internal rail defect detection.

[14] The T-10 car is a self-propelled vehicle that measures track geometry against Federal track safety standards. The basic parameters measured or calculated by the car include gage, cross-level, alignment, and rail profile and warp. The car also calculates limiting speed in curves.

instead of class 4 track. In Safety Board interviews, FRA track inspectors were asked if the inspection procedures required that the inspector check with the railroad track department to obtain the current track classification information before beginning an inspection. One FRA inspector replied, “Normally, we don’t. We use what we think to be the current timetable.”

The regional FRA inspector who conducted the November 18 inspection said she based the inspection on a timetable she had been provided by the FRA, which she believed to be the current UP timetable for the track. That timetable reflected the previous, class 3, classification. Before beginning the inspection, she did not check with the UP track department or request a copy of the latest timetable.

The November 18 test did not uncover any defects using class 3 standards. After the accident, Safety Board investigators reviewed the results of the FRA’s November 18 test and compared the results to the requirements for class 4 track. By class 4 standards, the test results revealed problems with gage, cross-level, track warp,[15] and surface alignment. The gage in three places was too wide; one gage exception was as much as 57.64 inches wide and 3 feet long.[16] The average super-elevation was 1.25 inches, which met standards for class 3 track but not for class 4, which required 3.25 inches. The track had warped where the cross-elevation changed quickly from 2 inches to level; the warped area was 1.91 inches wide and 17 feet long. The left (high) rail had a 1-inch dip, and the right (low) rail had a 1.38-inch dip. The alignment and surface of the track were irregular.

The UP director of track maintenance stated that he did not have any records or memory that undercutting, ballast cleaning, or soil stabilizing had ever been done within the area of the derailment on No. 1 main track.

On December 16, 1998, 4 days before the derailment, the UP manager of operating practices informed a manager of track maintenance of rough track in the area of MP 231. On the same day, the manager of track maintenance sent a crew consisting of a tamper operator and a ballast regulator operator to work in this area. The crew did not have a supervisor, and each worker was responsible for the quality control of his own work.

In a December 22, 1998, interview, the tamper operator said that after performing an initial plot of the curve with the tamping machine, he measured an average super-elevation of 0.75 inch. He said he decided to add an additional 0.75 inch elevation to the curve to bring it up to a 1.5-inch super-elevation. The 1.5 inches of super-elevation would have met the super-elevation requirement indicated on the curve chart on the machine. This super-elevation standard was based on a UP standard of 40 mph operation (appropriate for class 3 track) on a 2-degree 5-minute curve with a 1-inch unbalanced super-elevation.

[15] *Track warp* is the rate of change in elevation from the designated elevation over a specified distance in this curve that creates a twist in the rail vehicle.

[16] Maximum allowable gage for class 4 track is 57.5 inches.

In a follow-up interview on December 29, the tamper operator told investigators that before he started the December 16 work, the manager of track maintenance told him that the curve required 3.25 inches of super-elevation to meet the standards of class 4 track. The manager of track maintenance stated that he remembered telling the tamper operator to smooth out the curve, but he did not remember telling him to install 3.25 inches of super-elevation. In any event, the tamper operator stated that he did not believe sufficient ballast was available at the site to achieve the 3.25 inches of super-elevation. Repeating his earlier statements, he said that after plotting the curve with the tamper, he measured an average super-elevation of 0.75 inch and added an additional 0.75 inch to bring the super-elevation to 1.50 inches (which would meet class 3 track standards).

According to the ballast regulator operator, during the December 16 work, he had had to pull ballast from the tangent track to obtain even 9 inches of shoulder ballast on the curve. The UP engineering standards require that the shoulders have 12 inches of ballast and that the tie cribs be full.

The tamper operator said that after completing his work on December 16, he allowed one train to pass over the location at 10 mph. He then allowed a second train to pass over the location at 25 mph. After the second train, he did not impose any other speed restriction, and he did not report to his supervisor the amount of super-elevation he believed he had achieved at the site.

UP Chief Engineer Instruction Bulletin 134.4, "Raising Track," states:

> All automatic tampers are required to have a level board. This level board should be used frequently behind the machine to ensure correct cross-level in tangent [straight] track and super-elevation in curves.

The tamper operator had a level board, but he did not use it to verify the super-elevation that was being produced by his machine. He said he believed the machine had been operating as intended. The tamper operator stated that on the following day, December 17, he used the tamper at a different location. He did not operate the machine again before the derailment.

A relief tamper operator stated that he operated the same tamper on December 21, the day after the derailment. He stated that when he started to surface the curve in the area of the derailment, he noticed that the tamper was not producing the desired cross-elevation. The supervisor who was taking cross-level measurements behind the machine also detected the problem. The relief tamper operator said he inspected the machine and found that the surfacing actuator had loosened and slid down 1.5 inches. He repositioned the actuator and calibrated the machine, which then continued to work without any detectable problems.

Safety Board investigators could not determine whether the actuator had been improperly positioned when the work was done on December 16 or whether it had loosened while the tamper was in transit between locations. Investigators tested the effect of an out-of-position actuator on track super-elevation. Investigators set the machine up directionally and calibrated it as it was on December 16 and positioned the actuator as it was found on December 21. Testing showed that in this configuration and on tangent track, the tamper increased cross-elevation on the north rail. Although the machine was not tested on curved track because of the risk of significant damage to the track, the tamper manufacturer stated that if the track surface in a curve was bad before surfacing, it would be worse after being surfaced by a tamper with an actuator positioned as it was on December 21. No surface irregularities were reported in the area by either the track inspector or operating train crewmembers between December 16 and the morning of December 20.

The tamper manufacturer did not specify intervals at which to check the calibration of the machine but only advised calibrating whenever the performance of the machine, as verified by a level board, suggested that calibration was necessary. The UP required that the tampers have a daily maintenance inspection and an inspection and preventative maintenance servicing on a weekly (40 hours), monthly (150 hours), quarterly (500 hours), and annual basis (2,000 hours).

Safety Board investigators reviewed the daily preventative maintenance logs for October 1 through December 22. No previous actuator problems or necessary calibrations were noted in the comments. On December 14, the tamper operator had inspected the tamper but did not provide comments. On December 15, the tamper operator commented that the rear vibrator assembly had been replaced. On December 16, he had commented that a squeeze cylinder pin had been replaced. On December 17, the tamper operator inspected the machine but made no comments.

The monthly preventative maintenance log for the tamper was complete for June through November.

A UP track inspector stated that he inspected No. 1 main track every day by Hy-Rail vehicle.[17] The track in the derailment area had most recently been inspected by Hy-Rail vehicle at 10:00 a.m. on December 20 (9 hours before the derailment). The track inspector was operating a Hy-Rail vehicle on No. 1 main track during the inspection and did not note any exceptions in the area of the derailment. He stated that he normally worked by himself and operated the Hy-Rail vehicle at 30 mph. He also stated that he was not aware of any recurring track problems in the area of the derailment.

According to UP maintenance officials, between January and March 2001, about 150 crossties per mile were installed through the area in which the derailment occurred. In addition, new continuous welded rail is being installed between MP 216 and 231.2. The rail replacement is projected to be completed by the end of July 2001.

[17] In accordance with 49 CFR 213.233, track inspections can be made by foot or riding over tracks in a Hy-Rail vehicle at a speed that allows a visual inspection of the track structure. Movement of the Hy-Rail vehicle can also alert track inspectors to problems with super-elevation in curves.

Postaccident Inspection

According to FRA regulations, class 4 track must meet the following standards: the gage must be at least 56 inches and cannot exceed 57.5 inches; the alignment cannot deviate by more than 1.5 inches; and the difference in cross-level between any two points that are less than 62 feet apart cannot exceed 1.75 inches.

On December 20 and 21, 1998, Safety Board investigators measured the track geometry of No. 1 main track up to the point where the damaged track had been removed by maintenance personnel. The gage met the standards. The track was properly aligned except in an area just east of the point at which damaged track had been removed. Postaccident measurements revealed that the average super-elevation in the undamaged track was 0.61 inch. One location measured a reverse elevation (the inside rail of the curve higher than the outside rail) of 0.19 inch.

Tests and Research

Rail Tests

Eight sections of broken rail from the derailment site were sent to the UP Research and Development Laboratory in Omaha, Nebraska, where they were examined in the presence of Safety Board staff. All measurements complied with UP specifications.

Soil Analysis

The Safety Board contracted with Maxim Technologies, Inc., (Maxim)[18] to evaluate the site. As detailed in a May 26, 1999, report, Maxim determined that the soil in the vicinity of the derailment comprised highly plastic clays having a very high shrink/swell potential. The deposits are subject to volume changes when their moisture content changes. Dry weather and drought are known to cause soil to shrink, resulting in a lowering of the ground surface and subsequent track settlement. Rainy weather is known to increase the amount of moisture in the soil, causing it to swell. Such shrinking and swelling of soil in the subgrade can cause changes in track geometry or super-elevation.

Signal System Tests and Inspection

On December 21, 1998, field inspections and testing were performed on the traffic control system in the accident area. Representatives from the Safety Board, the FRA, the UP, and Amtrak were present. The inspectors did a visual inspection and ground test of the signal equipment for the route.

At the time of the test, the electronic track circuit units were transmitting the proper codes. The signal system transmitted codes in a logical progression when tested, and the displayed signal aspects matched the transmitted codes.

[18] Maxim is a soils engineering company that analyzes soil for a variety of industries, including railroads.

UP signal maintenance, inspection, and test records indicated that the equipment was in satisfactory operating condition with no exceptions reported.

Radio Communications

Radio coverage in the Dallas subdivision is maintained through radio towers owned by the Burlington Northern Santa Fe Railroad and located in Forth Worth and Irving, Texas. The UP, through a lease agreement, uses the towers in its communications system.

The UP train dispatcher, located in Fort Worth, uses a computer monitor that displays a box for each tower and each radio channel available for communicating with railroad personnel. When there is a radio transmission, the corresponding box changes color. The dispatcher determines which channel to monitor and can listen and transmit on the selected channel.

The lead locomotive on Amtrak train 22 (the train that passed through the accident area ahead of train 21, which derailed) was equipped with an Aerotron Alpha 1597 Clean Cab transceiver radio. All controls and indicators are on the radio's front panel. Because the radio is designed for continuous operation, it does not have an on/off switch and operates as long as power is supplied. Audio input is through a built-in microphone or an external telephone-type handset. Audio input is activated when the push-to-talk button on the front panel or the telephone handset is depressed.

The radio also has a 12-button touch pad that is mounted on the speaker grill area and used to send out dual-tone multi-frequency (DTMF)[19] tone sequences. When any key on the pad is depressed, the transmitter is automatically keyed. Holdover timing of the transmitter key line (approximately 2 seconds) is provided so that the transmitter will not un-key between digits of a tone sequence.

If, because of radio traffic or other reasons, engineers operating on UP tracks in the Dallas subdivision cannot reach the train dispatcher by radio, they can press the number "5" on the radio keypad and alert the dispatcher, who will then radio the train as soon as possible. The radio on train 22 also had a dispatcher call or tone button, which is on the front panel and is labeled "DISP."[20] This button can be programmed to transmit the appropriate tone (in this case, "5") whenever it is pressed. The engineer of train 22 said he was familiar with the operation of the DISP feature, and he knew that the dispatcher could be contacted by pressing "5" on the keypad. He did not use either method when he attempted to alert the dispatcher to the kink in the rail he had observed before train 21 derailed.

[19] A DTMF system generates a combination of two tones, one high frequency and one low frequency, whenever a button is pressed.

[20] The DISP button on a railroad radio is reserved to deliver a pre-programmed and timetable-specified DTMF tone for alerting or calling a dispatcher.

On February 17, 1999, the lead locomotive radio was bench tested at the Amtrak radio shop in Chicago. Representatives from the Safety Board, the FRA, the UP, and Amtrak were present. At the time of the test, the radio was operating within specifications.

After the accident, Amtrak revised its "Amtrak Intercity Standards for Engineers and Conductor Qualifications" to include specific test items related to using the radio to contact train dispatchers. For the written examination portion, candidates for qualification over a specific territory must:

> Identify each dispatcher and limits of their authority; radio frequencies in use and method used to reach the dispatcher or control operator(s).

The revised oral portion of the qualification examination for engineers includes the following:

> Names of subdivision(s) and exact limits of each subdivision. Discuss exact procedures used to 'tone' dispatchers(s), where and how to get GOs [general orders]/Bulletins/Train Messages, etc.

Operations Information

According to *General Code of Operating Rules* rule 6.21.1,[21] "Protection Against Defects," if any defect or condition that might cause an accident is discovered on tracks, bridges, or culverts, or if any crewmember believes that the train or engine has passed over a dangerous defect, the crewmember must immediately notify the train dispatcher and provide protection, such as a flagman, if necessary.

Rule 20.3, "Immediate Warning of Hazard," in *Union Pacific Rules Governing Train Dispatchers*, states that when train dispatchers learn of any condition or practice that may harm employees or others or affect the safety of train operations, they must:

- Immediately warn all concerned, including trains en route, using the quickest means of communication available.
- Advise all concerned in an emergency situation to use the radio only when absolutely necessary.
- Be sure that necessary track bulletins or other safeguards are provided as soon as possible.

After the Arlington derailment, the UP issued the following bulletin:

> The UP's Train Dispatcher's Bulletin No. 60 of December 21, 1998

[21] The *General Code of Operating Rules* is used by signatory railroads to govern the operation of their trains. The General Code of Operating Rules Committee meets several times a year to discuss rules and proposed changes.

Addition to Operating Rule 21.9, Protection of Defects:

When a report is received of rough track (not reported as a broken rail), train dispatcher must do the following:

- Determine location of defect.
- Immediately advise any train approaching the reported defect on the same track to reduce to restricted speed, not exceeding 10 MPH at the location.
- If in [centralized traffic control] or manual interlocking, place blocking device to prevent signals from clearing into the affected track until all trains requiring the restriction have been advised.
- Notify appropriate Manager of Track Maintenance.
- Continue to require all train movements to be made at restricted speed, not exceeding 10 MPH until advised by a qualified employee that the restriction is no longer required.
- If in doubt as to whether the reported rough track is passable, stop trains until advised by a qualified employee that it is safe for movement.

When a report is received of a possible broken rail, train dispatcher must do the following:

- Determine location of defect.
- Immediately advise any train approaching the reported defect on the same track to stop before passing over location and not proceed until authorized by a qualified employee.
- If in [centralized traffic control] or manual interlocking, place blocking device to prevent signals from clearing into the affected track until all trains requiring the restriction have been advised.
- Notify appropriate [manager of track maintenance].
- Do not authorize train to pass over broken rail until advised by a qualified employee that it is safe to do so.

Dissemination of Speed Change Information

According to UP officials, any change in maximum authorized speed over a section of track, such as resulted from the reclassification of the accident track from class 3 to class 4 in 1998, is issued by the superintendent of operations in the form of a general order. If the speed change is permanent, as this one was, it is reflected in an updated timetable for this division. The superintendent issues the change only after the manager of track maintenance and/or the director of track maintenance has inspected the track. The manager of track maintenance is responsible for notifying everyone under his direction of the speed change, which he normally does, UP officials said, during a general safety meeting. The officials said it is the responsibility of maintenance-of-way employees to access any general order information through the station computer system.

Curve charts, such as the one used by the tamper operator to resurface the track 4 days before the accident, are issued once a year from the engineering department, via the station computer system, to all maintenance employees. In the meantime, UP officials said, an employee doing work on a segment of track, such as the tamper operator, is responsible for reviewing the general orders or timetable and for comparing the allowable track speed to the UP maintenance-of-way rule book to get the proper super-elevation information. The tamper operator who resurfaced the accident area on December 16, 1998, did not update the track chart before beginning work.

Meteorological Information

According to the National Weather Service, the weather at Dallas-Fort Worth International Airport (approximately 10 nautical miles from Arlington) on December 20 at 6:53 p.m. central standard time was as follows: winds were from the south-southeast at 5 knots, visibility was 1/4 statute mile under fog conditions, and the temperature was 50º F.

The crew on train 21 reported that before the accident it was foggy and dark and that the temperature was 40° to 50° F.

According to the records from the National Climatic Data Center, the Dallas/Fort Worth area had a drought during the summer of 1998 that continued into October. The drought was one of the worst on record and was followed in November and December 1998 by a period of rainy weather.

Medical and Pathological Information

Injury Sources

No serious injuries or fatalities resulted from this accident, and all patients were treated for minor injuries and released. Passengers who were injured sustained their injuries from being thrown about during the derailment and striking interior surfaces, including the seat backs in front of them. A total of 22 people (12 passengers and 10 crewmembers)[22] were transported to hospital facilities for medical attention.[23]

[22] The number of documented medical transports by the municipal ambulance service differs from the total treated at medical facilities because several family members accompanying patients were later evaluated by hospital personnel, and several persons were transported to the hospital by private automobile, rather than being transported by the municipal ambulance service.

[23] Defined as medical assessment and/or treatment.

Toxicological Testing

During Safety Board interviews, each of the crewmembers of train 21, with the exception of the relief engineer, said he had not used alcohol or drugs, including prescription or over-the-counter medication, for several days before the accident. The relief engineer stated that he had taken medication to control hypertension. The dispatcher also said he had not used alcohol or drugs before the accident. The dispatcher took medication to control diabetes; the dispatcher's doctor told the Safety Board that this medication would have had no effect on his job performance.

Pursuant to 49 CFR 219, Subpart C (FRA chemical testing regulations), six Amtrak employees and the dispatcher on duty at the time of the accident provided specimens for toxicological testing. NWT Drug Testing of Salt Lake City, Utah, did the testing. The specimens were screened for cannabinoids, cocaine, opiates, amphetamines, methamphetamines, phencyclidine, barbiturates, benzodiazepines, and ethyl alcohol. All results were negative.

Event Recorders

The lead locomotive of train 21 was a General Electric (GE) integrated function control locomotive, type P42. The event recorder on the locomotive was a Pulse solid state integrated function control (IFC) recorder. The data from the event recorder showed anomalies in recorded speed.[24] For example, between recorder time 20:44:53 and 20:45:00, the following speeds were recorded: 29, 58, 58, 58, 39, 39, 39, and 43 mph. Such fluctuations over a period of only 7 seconds are not possible for a train of this size. A copy of the data was sent to Pulse for analysis. Pulse then forwarded the information to GE, where GE technicians discovered a timing malfunction within the locomotive's IFC microprocessor. GE developed and implemented a software upgrade for all locomotives with this problem.

The second locomotive of train 21 was equipped with a Bach Simpson speed information system, paper tape, model BF8A. This locomotive was restricted to trail position only while operating on intercity trains, and the paper speed recorder was not operating.

The third of the three locomotives had an Aeroquip speed information system magnetic tape recorder that recorded on a pulse tape. The recorder and the tape were sent to the Safety Board's laboratory for testing and evaluation. The data from the locomotive showed anomalies in recorded speed. This recorder has been taken out of service.

[24] Although the event recorder showed some speed anomalies, investigators used this data in conjunction with engineer statements and communications and signal timing data to determine that the derailment occurred at about 36 mph.

FRA regulations do not require trailing locomotives to have event recorders, and Amtrak did not maintain the event recorders on the trailing locomotives.

Analysis

Exclusions

At the time of the accident, the weather was damp and cool, with light fog. No evidence was found to indicate that reduced visibility was a factor in the accident. The Safety Board therefore concludes that the weather and visibility at the time of the accident were not causal or contributory to the accident.

The engineer of freight train ILBMN-18 was passing through the accident area at slightly less than the maximum authorized speed when he encountered and then reported rough track. The operating crews of the two Amtrak passenger trains, in response to warnings by the UP dispatcher, slowed their trains to about one-half the maximum authorized speed as they passed through the area of the reported rough track. The Safety Board therefore concludes that the derailment was not caused by a deficiency in the crews' operation of their trains.

All required preaccident train inspections and testing of all train equipment were satisfactorily accomplished. Additionally, postaccident inspections and tests did not reveal any mechanical defects that might have contributed to the accident. Postaccident examination of rail samples revealed no metallurgical defects. All damage to the rail was consistent with the damage caused by derailment overload. Therefore, the Safety Board concludes that the derailment was not caused by a mechanical failure of any locomotive or passenger car equipment or by any defect in the rail.

Postaccident toxicological testing of the Amtrak crew and the UP dispatcher was negative for alcohol and drugs and, according to the dispatcher's physician, the prescription medications used by the dispatcher to control his diabetes would not cause any impairment. The Safety Board therefore concludes that neither alcohol or drug use nor the use of prescription medications was a factor in this accident.

Accident Analysis

Almost 3 hours before the derailment, an eastbound freight train crew reported to the train dispatcher that they had encountered rough track on main track No. 1 in the area of MP 231. The dispatcher did not relay the report to the track department or request that a track inspector or crew be sent to check the condition of the track. A few minutes behind the freight train was eastbound Amtrak train 22. The dispatcher radioed the engineer of train 22 that rough track had been reported at MP 231 and that he should be "governed accordingly." The Amtrak engineer slowed the train to about 35 mph as he approached the area. He said that as he passed the location of the reported rough track and began to accelerate, he observed what he described as a "kink" in the rail just east of MP 231. He successfully transited the area at between 25 and 30 mph. The engineer said he was unsuccessful in reaching the dispatcher by radio and thus did not provide a report of the observed rail defect or its location to the dispatcher.

The engineer of train 22 said he attempted to contact the dispatcher by keying the handset and making a regular radio transmission. He did not use the more effective method of pressing “5” on the radio keypad or the pre-programmed “DISP” key. Had he done either, the dispatcher would have been instantly alerted that train 22 was attempting to contact him, and he could have called the train at the first opportunity. Had the dispatcher done so and been informed that train 22 had encountered what the crew described as a “kink” in the rail, he may have been prompted to call the track department immediately or, at a minimum, he may have put a slow order on that section of track until the track department could investigate. Such a restricted speed could have prevented the accident. The Safety Board therefore concludes that if the engineer of Amtrak train No. 22 had contacted the dispatcher and notified him of the track defect the crew had observed, the dispatcher may have taken action that could have prevented this accident. Since the accident, Amtrak has revised its written and oral qualification tests to require that its engineers demonstrate specific knowledge of the subdivisions and dispatchers responsible for the relevant territory and of the various methods of contacting dispatchers, including using the “tone” procedure.

About 2 1/2 hours after the passage of train 22, westbound Amtrak train 21 approached the area of reported rough track. The engineer had been advised of the report by the dispatcher, and he slowed his train as he approached MP 231. Although it cannot be known with certainty, the previous passage over the area by the eastbound freight and passenger train could have exacerbated the track problem and lowered the safe speed for subsequent trains. In any event, as train 21 transited the curve at about 36 mph near MP 231, it derailed. The Safety Board thus concludes that the reduced speed at which Amtrak train No. 21 attempted to transit the area of the previously reported rough track was greater than the condition of the track could support, causing the train to derail in the curve near MP 230.62.

Safety Board investigation of the accident revealed that the track on which the derailment occurred had been upgraded from class 3 to class 4 track less than 2 months before the accident. But the investigation also revealed that the track had not been maintained to class 4 standards and that the super-elevation at times did not meet class 3 standards. The investigation identified the following safety issues:

- The adequacy of the UP’s procedures for responding to train crews’ reports of track problems;
- The adequacy of the UP’s oversight of track maintenance; and
- The adequacy of the UP’s procedures for communicating changes in track classifications.

Handling of Reported Track Problems

When the eastbound freight train reported rough track, the dispatcher did not place a speed restriction on the area, nor did he notify track maintenance personnel and ask that the track be checked. He stated that he did not believe the warning from the freight train was serious enough to warrant delaying trains so that the track could be inspected, but he did plan to notify the track department after the two Amtrak trains had cleared the area. But he had no way of knowing the actual condition of the track or if that condition had been further degraded by the passage of the freight train itself. He had the authority to put a speed restriction in place at the location of the reported rough track, but he did not do so. A speed restriction of 10 mph, for example, may have been appropriate until the actual condition of the track could be determined. In the almost 3 hours that elapsed between the initial report and the derailment, the UP track department may have had ample opportunity to inspect the track and evaluate its safety. Even if immediate repairs were not possible, the speed restriction may have allowed safe passage until repairs could be made. The Safety Board therefore concludes that if the dispatcher had implemented an appropriate speed restriction and/or notified track maintenance personnel immediately after he received the report of rough track, the accident may not have occurred.

The day after the accident, the UP added additional requirements to its Operating Rule 21.9 via Train Dispatcher's Bulletin No. 60 for the Protection of Defects, requiring the dispatcher to immediately advise any train approaching an area that had been reported to have a defect on the same track to reduce its speed to no more than 10 mph and to notify the appropriate manager of track maintenance. A Safety Board survey of the policies and practices of other class I railroads indicated that they require the train dispatcher to immediately call a track supervisor after receiving a report of rough track. These policies generally require that if a train reaches the rough track location before a track supervisor can evaluate the track, the train must stop and protect the location. Once stopped and once a supervisor—or, possibly, the crew—determines that the track is safe, the train may proceed at restricted speed. The survey revealed that the UP, the Burlington Northern Santa Fe Railroad, and Amtrak[25] each have a specific operating rule or written dispatcher instruction that addresses events such as occurred in this accident.

The Safety Board is concerned that the guidance for dispatchers at most railroads does not have the force of a rule and therefore may not be adequate to ensure maximum safety for operating crews and intercity train passengers. The Safety Board therefore believes that the Association of American Railroads and the American Short Line and Regional Railroad Association should inform their member railroads of the circumstances of the December 20, 1998, derailment in Arlington, Texas, and urge them to ensure that their rules require train dispatchers, upon receiving reports of track problems, to immediately implement an appropriate speed restriction for the affected area and to immediately notify track maintenance personnel of the reported condition.

[25] Amtrak owns and controls only a small segment of its overall route structure. Where Amtrak operates over other rail lines, it must follow the procedures of the host railroad.

UP Track Maintenance Oversight

UP managers of track maintenance told the Safety Board that the accident area was a high-maintenance area in which track crews found it difficult to maintain track cross-level and alignment. The engineer of train 22 told investigators that the track in the accident area had always been "a little rough." An engineering evaluation of the subgrade (the finished earthen surface of the roadbed below the ballast and track) in the area indicated the presence of "plastic" clay-type soils that exhibit a tendency to shrink in dry conditions, then expand when moisture is returned to the material. Such physical changes in the subsurface soil could be transmitted to the running surface of the track. These changes might cause track conditions that train crews describe as "rough track."

Meteorological conditions in the Arlington area during several months preceding the accident included a drought followed by a period of significant rain. Such conditions are conducive to the changes in subgrade soil described above. Fluctuations in the subgrade, combined with the effects of high-speed, high-tonnage train traffic, can significantly alter a track's load-bearing capacity. Postaccident measurements revealed that the average super-elevation in the undamaged track near the accident site was 0.61 inch. One location measured a reverse elevation of 0.19 inch. Using the average of these measurements in calculations prescribed in 49 CFR 213.57, investigators determined that the track leading to the accident site was capable of supporting passenger train speeds of about 50 mph, which was 10 mph slower than trains normally operated over this section of track. In this case, train 21 derailed at 36 mph, indicating that the reverse elevation and track warp were even greater nearer the point of derailment.

The statements of the managers of track maintenance and the evidence developed during this investigation confirmed that the accident area was problematic. For example, in the 2 months preceding the accident, significant changes in track super-elevation occurred. At the end of October 1998, the super-elevation was 3.25 inches, in accordance with the UP's redesignation of the track from class 3 to class 4. On November 18, the FRA inspected the track with a T-10 car and found that the average super-elevation of the curve had dropped to 1.32 inches, which was sufficient to meet only class 3 standards. (With this amount of super-elevation, the maximum authorized speed for freight trains should have been 40 mph rather than the 60 mph authorized by the UP for this track.) On December 16, after rough track was reported, the super-elevation was measured as 0.75 inch and was resurfaced to bring it to 1.5 inches. On December 20, just hours before the derailment, crewmembers from two trains felt and observed rough track, likely indicating another change in super-elevation. Finally, just after the derailment, the average super-elevation in the accident area was measured as 0.61 inch, with one location measuring a reverse elevation of minus 0.19 inch. The movement of the track from a super-elevation on December 16 to a reverse elevation on December 20 represented a change of 1.69 inches in just 4 days. (Between December 16 and December 20, the area had received almost an inch of rain.) Considering the nature of the soil in the vicinity of the derailment site, the drought in the area, and the wet weather before the derailment, the Safety Board concludes that increases in subgrade soil moisture under the derailment area could have caused the changes in track geometry that led to the accident. The Safety Board believes that the UP should develop an action plan to address known subgrade problems on the Dallas subdivision.

Several solutions are available to the problem of maintaining surface profile, cross-elevation, and super-elevation of track on a subgrade that is subject to shrinking and swelling. Some, such as chemical stabilization, are long term. Chemical stabilization consists of pumping chemical slurry deep into the ground; the slurry reacts with subgrade soil and reduces its affinity for water. Another long-term solution is to drive pilings into the embankment to keep the subgrade from spreading out or widening beneath the track structure. Other long-term solutions include excavating the roadbed and installing drainage systems using either geo-synthetic fabric to control water run-off or honeycomb ballast containment systems.

The UP chose a short-term solution—adding ballast as needed. Ballast promotes track stability by anchoring the track in place against lateral, vertical, and longitudinal movement and by transmitting the load of the track and railroad traffic over the subgrade with diminished unit pressure. Done properly, adding ballast can be an effective way to maintain track surface, but only if the area to which the ballast is applied is closely monitored for traffic (tonnage) and subsequent movement of the track. The railroad must be prepared to add more ballast as frequently as is necessary. Based on the evidence gathered in this investigation, the UP did not adequately monitor track conditions in the accident area. The rapidity of the changes should have alerted the UP to the necessity of constantly checking the amount of the ballast and increasing the amount as necessary.

On December 16, 4 days before the accident, the super-elevation had dropped to 0.75 inch, and the tamper operator said insufficient ballast would have been available to bring the super-elevation to 3.25 inches. The ballast regulator operator also noted that insufficient ballast was available to provide the required 12 inches of ballast shoulder on the curve. Postaccident investigation found that the tie cribs were not full of ballast near the rails and that the shoulder area contained only 8 inches of ballast. Insufficient ballast in the tie cribs and at the tie shoulder can allow the track, under certain conditions, to develop a kink of the type the engineer of train 22 said he observed shortly before train 21 derailed. Insufficient ballast under the tie can also reduce the bearing capacity of the subgrade soil. After the accident, 27 to 30 carloads of ballast were required to return the track to the proper super-elevation in the accident area.

A track bed normally acquires both vertical and lateral stability as train traffic compacts it; however, much of this stability is lost when the track is disturbed, as it is by tamping. According to railroad industry standards, about 1 million tons of train traffic is required to stabilize track properly after it has been disturbed by resurfacing.[26] On December 16, upon completing his work, the tamper operator allowed one train to pass over the location at 10 mph. He then allowed a second train to pass over the location at 25 mph. No other speed restrictions were imposed. Even if the two trains that transited the area at reduced speeds were high-tonnage trains, their total weight would not likely have exceeded about 30,000 tons, which is far short of the amount required for optimum

[26] Simmons-Boardman Publishing Corporation, *Railway Track and Structures, 1998*.

compaction and stabilization of the track. If the track was not adequately compacted by train traffic before trains were allowed to operate at 60 mph, the development of track irregularities may have been accelerated, and these irregularities could have been the source of the rough track reported in the hours before the accident on December 20.

On the day after the derailment, a relief tamper operator working to repair the derailment damage attempted to use the tamper machine that had been used to resurface the track 4 days before the accident. He found that he could not resurface the track accurately because the actuator on the machine was improperly positioned. The investigation could not determine conclusively whether the actuator had been misaligned when the December 16 work was performed or whether the misalignment had occurred when the machine was in transit. Based on statements of the tamper operator and the machine manufacturer, and the fact that no track problems were reported between December 16 and December 20, the misalignment most likely occurred after the work on December 16. But the tamper operator could not have been certain on December 16 that the machine was operating properly and providing the correct super-elevation because, even though UP maintenance procedures required it, he did not use the level board on his machine to verify his work, and the job was not assigned a supervisor who could have performed quality control.

Although track managers said that this was a high-maintenance area, the track inspector, who rode the track in the area twice weekly in a Hy-Rail vehicle, stated that he was not aware that the area was particularly problematic. He used his standard inspection procedures for this area and did not, for example, note any anomalies in the track surface when he inspected the track 6 hours before the rough track report and 9 hours before the derailment.

Thus the investigation revealed that the UP did not ensure (1) that sufficient ballast was available in the accident area to achieve the appropriate super-elevation, (2) that the tamper operator verified his work after resurfacing the track and that he took the necessary action to ensure that the track bed was sufficiently stabilized before trains were allowed to operate at the maximum allowable speeds, and (3) that track inspection procedures were adequate to identify track surface irregularities in an area identified by UP track maintenance managers as problematic. The Safety Board therefore concludes that in the months leading up to the accident, the UP did not exercise adequate management oversight of its track inspection and maintenance programs on this portion of the Dallas subdivision.

The Safety Board believes that the UP should revise its track maintenance policies and practices to establish quality control procedures for track repair and maintenance activities. These procedures should be designed to ensure that the type of maintenance to be performed is appropriate to address the specific problem and that the maintenance itself is performed correctly.

UP Procedures for Upgrading Track Classification

Even if the tamper machine worked perfectly on December 16 and the super-elevation was accurately raised from 0.75 inch to 1.5 inches, this would have been insufficient for safe operation of trains at 60 mph. The UP had upgraded the track to class 4 in late October, but the tamper operator was apparently unaware of the reclassification. In a second Safety Board interview, the tamper operator said his supervisor had told him before he began his work in the accident area on December 16 that he would need to bring the super-elevation in the curve to 3.25 inches. This would have been consistent with requirements for class 4 track. But the supervisor stated that he did not remember giving the tamper operator such an instruction, and the instruction was not mentioned by the tamper operator in his more contemporaneous interview 2 days after the accident. Furthermore, the tamper operator had only enough ballast to raise the super-elevation to 1.5 inches. Had he been given specific instructions to raise the elevation by more than twice that amount, he would likely have informed his supervisor that he could not. That he did not inform his supervisor suggests that he was not told to bring the super-elevation to 3.25 inches but only to resurface the curve. Finally, the curve chart available to the tamper operator reflected the super-elevation requirements of class 3 track, which the tamper operator said he was able to achieve. The Safety Board concludes that because the tamper operator who resurfaced the track in the accident area 4 days before the derailment was not aware that the track had been designated class 4 track, he did not raise the track super-elevation the amount that was necessary for the higher classification or that was appropriate for the train speeds the UP had authorized for this track.

According to the UP, maintenance-of-way employees, such as the tamper operator, are required before beginning work to review the general orders or timetable and for comparing the allowable track speed to the UP maintenance of way rule book to get the proper super-elevation information. The tamper operator did not update the information before resurfacing the curve on December 16, and the UP had no effective procedure in place to verify that its track maintenance employees always obtained the latest track information before beginning work. The Safety Board therefore concludes that the UP's procedures were inadequate for ensuring that information about changes in track classification were communicated in a timely fashion to all of its track inspection and maintenance personnel. The Safety Board believes the UP should revise its procedures for disseminating documentation for the current classification of track to all track inspection and maintenance employees so that up-do-date information is available to them when they inspect, repair, or maintain the track.

The FRA track inspector was also unaware of the reclassification when the FRA inspected the track on November 18. The inspector could have determined the correct classification, however, by checking with the UP track department or simply by obtaining a copy of the current timetable before beginning the inspection. She was not required by FRA procedures to do so, however, so she instead relied on an outdated timetable provided by the FRA.

Because the FRA inspection was conducted against parameters appropriate for class 3 track, the inspection did not reveal track conditions (such as a 1.32-inch super-elevation in the accident curve) that would have prevented the UP from legally operating trains at the 60 mph speed authorized at the time. In addition to the insufficient super-elevation (by class 4 standards), subsequent Safety Board analysis of the T-10 car data showed track warp and gage deviations that would have prevented the track from being operated as class 4 track. The Safety Board therefore concludes that FRA track inspection procedures were inadequate to ensure that track inspectors obtain up-to-date track classification information before beginning an inspection, with the result that the November 18, 1998, FRA inspection of the accident track did not reveal deficiencies that would have required either corrective action or a lowering of the maximum authorized speed. The Safety Board believes that the FRA should revise its track inspection procedures to ensure that all FRA track inspectors obtain current track classification documentation before they inspect a track.

Conclusions

Findings

1. The weather and visibility at the time of the accident were not causal or contributory to the accident.

2. The derailment was not caused by a deficiency in the crews' operation of their trains.

3. The derailment was not caused by a mechanical failure of any locomotive or passenger car equipment or by any defect in the rail.

4. Neither alcohol or drug use nor the use of prescription medications was a factor in this accident.

5. The reduced speed at which Amtrak train No. 21 attempted to transit the area of the previously reported rough track was greater than the condition of the track could support, causing the train to derail in the curve near milepost 230.62.

6. If the engineer of Amtrak train No. 22 had contacted the dispatcher and notifyed him of the track defect the crew had observed, the dispatcher may have taken action that could have prevented this accident.

7. If the dispatcher had implemented an appropriate speed restriction and/or notified track maintenance personnel immediately after he received the report of rough track, the accident may not have occurred.

8. Increases in subgrade soil moisture under the derailment area could have caused the changes in track geometry that led to the accident.

9. In the months leading up to the accident, the Union Pacific Railroad did not exercise adequate management oversight of its track inspection and maintenance programs on this portion of the Dallas subdivision.

10. Because the tamper operator who resurfaced the track in the accident area 4 days before the derailment was not aware that the track had been designated class 4 track, he did not raise the track super-elevation the amount that was necessary for the higher classification or that was appropriate for the train speeds the Union Pacific Railroad had authorized for this track.

11. The Union Pacific Railroad's procedures were inadequate for ensuring that information about changes in track classification were communicated in a timely fashion to all of its track inspection and maintenance personnel.

12. Federal Railroad Administration (FRA) track inspection procedures were inadequate to ensure that track inspectors obtain up-to-date track classification information before beginning an inspection, with the result that the November 18, 1998, FRA inspection of the accident track did not reveal deficiencies that would have required either corrective action or a lowering of the maximum authorized speed.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the December 20, 1998, derailment of Amtrak train No. 21 in Arlington, Texas, was (1) track conditions that were inadequate for the speed of the train, (2) the decision of the dispatcher to delay notifying track department personnel that a train crew had reported encountering rough track, (3) the inadequate effort on the part of the engineer of Amtrak train 22 to contact the dispatcher to report the observed track defect and its location, (4) the failure of the tamper operator to adequately resurface the track 4 days before the accident, (5) inadequate Union Pacific Railroad oversight of track maintenance work on this section of track, and (6) inadequate Union Pacific Railroad requirements for restricting train speed over track with reported rough conditions until track department personnel can assess track condition.

Recommendations

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

To the Federal Railroad Administration:

> Revise your procedures to ensure that all Federal Railroad Administration track inspectors obtain current track classification documentation before they inspect a track. (R-01-12)

To the Association of American Railroads:

To the American Short Line and Regional Railroad Association:

> Inform your member railroads of the circumstances of the December 20, 1998, derailment in Arlington, Texas, and urge them to ensure that their rules require train dispatchers, upon receiving reports of track problems, to immediately implement an appropriate speed restriction for the affected area and to immediately notify track maintenance personnel of the reported condition. (R-01-13)

To the Union Pacific Railroad:

> Revise your procedures for disseminating documentation for the current classification of track to all track inspection and maintenance employees so that up-do-date information is available to them when they inspect, repair, or maintain the track. (R-01-14)

> Develop an action plan to address known subgrade problems on the Dallas subdivision. (R-01-15)

> Revise your track maintenance policies and practices to establish quality control procedures for track repair and maintenance activities. These procedures should be designed to ensure that the type of maintenance to be performed is appropriate to address the specific problem and that the maintenance itself is performed correctly. (R-01-16)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CAROL J. CARMODY
Acting Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

Adopted: July 24, 2001

Appendix

Investigation and Depositions

The Safety Board was notified of this accident about 9:30 p.m., eastern standard time, on December 20, 1998, and dispatched a major railroad accident investigation team. Investigative groups examined the operation, track, signals, radio communications, mechanical, survival factors, human performance, and event recorder aspects of the accident.

The Union Pacific Railroad, the National Railroad Passenger Corporation, the Federal Railroad Administration, and the Railroad Commission of Texas (all parties to the investigation) assisted in the Safety Board investigation.

As part of its investigation, the Safety Board conducted a 1-day deposition proceeding in Arlington, Texas, on June 30, 1999, at which 12 witnesses testified.

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