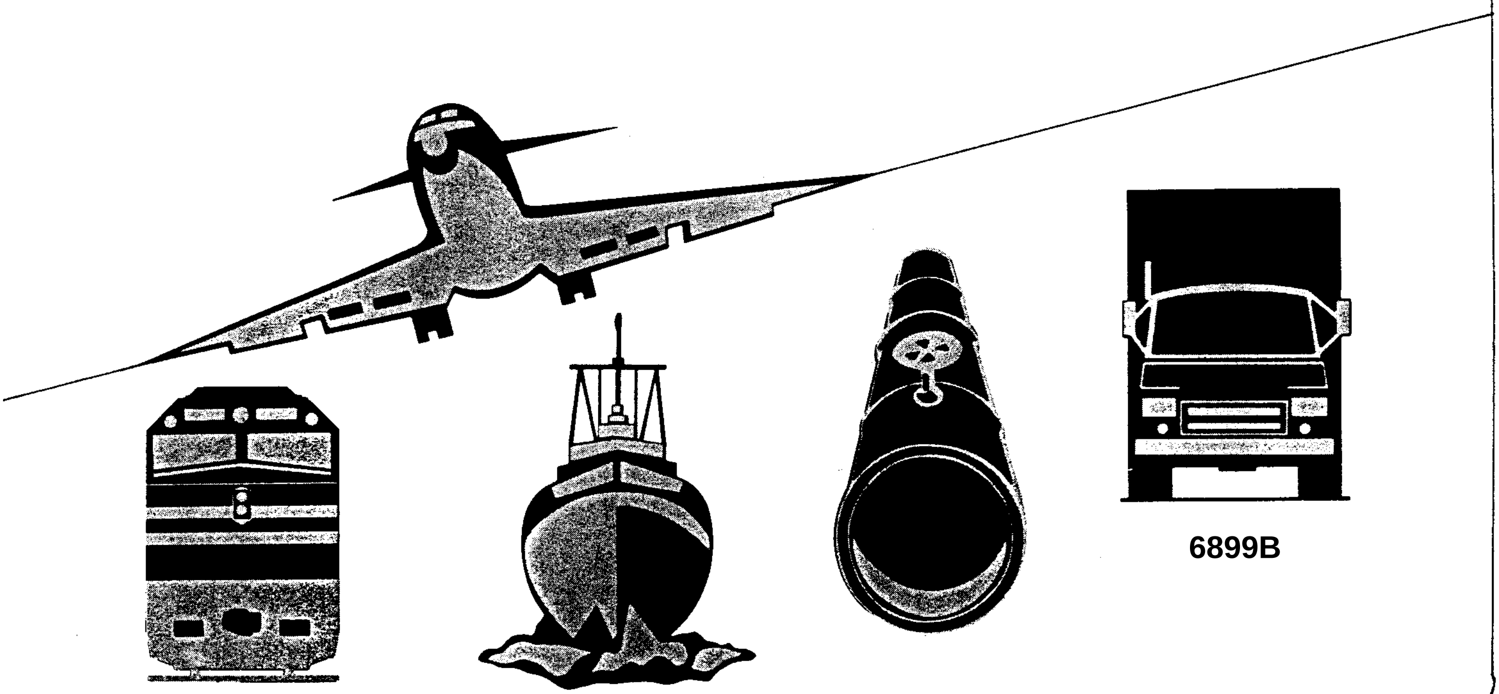
PB99-916304
NTSB/RAR-99/04

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

COLLISION BETWEEN UNION PACIFIC FREIGHT TRAINS MKSNP-01 AND ZSEME-29 NEAR DELIA, KANSAS JULY 2, 1997



6899B

National Transportation Safety Board. 1999. *Collision between Union Pacific Freight Trains MKSNP-01 and ZSEME-29 near Delia, Kansas. July 2, 1997.* Railroad Accident Report NTSB/RAR-99/04. Washington, DC.

Abstract: This report explains the collision of Union Pacific freight trains MKSNP-01 and ZSEME-29 near Delia, Kansas, on July 2, 1997. One crewmember was killed, and 1 crewmember sustained minor injuries as a result of this accident. Damages related to the accident exceeded $5.1 million.

From its investigation of this accident, the Safety Board identified safety issues in the following areas: the MKSNP-01 engineer's performance, the Union Pacific Railroad's fatigue education program, crew resource management, and positive train separation control systems. Based on its findings, the Safety Board made recommendations to the Federal Railroad Administration, the Union Pacific Railroad, the Brotherhood of Locomotive Engineers, and the United Transportation Union.

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Railroad Accident Report

Collision between Union Pacific Freight Trains MKSNP-01 and ZSEME-29 near Delia, Kansas July 2, 1997

NTSB/RAR-99/04
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Notation 6899B
Adopted: August 31, 1999

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
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Executive Summary

About 2:15 a.m., July 2, 1997, westbound Union Pacific (UP) freight train NP-01, operating on a siding track, proceeded past a wayside stop signal at the end of the siding and collided with the side of eastbound UP freight train ME-29, which was operating on a mainline track on the UP railroad near Delia, Kansas. The NP-01 train engineer was killed, and the NP-01 train conductor sustained minor injuries.

The National Transportation Safety Board determines that the probable cause of this collision and derailment was the failure of the of the NP-01 engineer to stop at the stop signal, enabled by the failure of UP management to ensure redundant safety systems for train operations and control, including effective crew resource management techniques and technological advances for crew alertness. Contributing to the collision and derailment was the failure of the Federal Railroad Administration (FRA) and the railroad industry to aggressively develop and implement a positive train separation (PTS) control system.

The major safety issues discussed in this report are the NP-01 train engineer's performance, crew resource management, the UP's fatigue education program, and PTS control system.

As a result of its investigation of this accident, the Safety Board makes recommendations to the FRA, the UP, the Brotherhood of Locomotive Engineers, and the United Transportation Union.

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Factual Information

Accident Synopsis

On July 2, 1997, about 2:15 a.m., westbound Union Pacific (UP) freight train MKSNP-01 (NP-01) collided with the side of eastbound UP freight train ZSEME-29 (ME-29) where the Kenefick siding track merges with the main track on the UP railroad near Delia, Kansas, (figure 1). Each train was staffed by an engineer and a conductor. The NP-01 train engineer was killed, and the NP-01 train conductor sustained minor injuries.

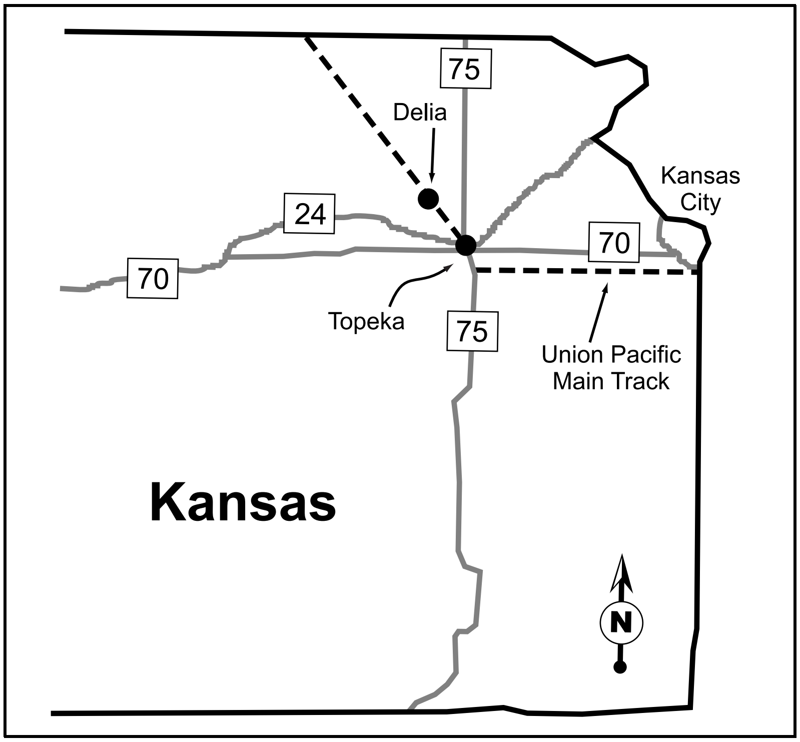


Figure 1. Collision occurred near Delia, Kansas.

Accident Narrative

Train NP-01, originally consisting of 2 diesel locomotive units and 68 cars, departed UP's 18th Street Yard in Kansas City, Kansas, at 10:10 p.m. for North Platte, Nebraska.[1] About 11:15 p.m., the train stopped at Bonner Springs, Kansas, where the crew added 22 loaded auto-rack cars. At 12:10 a.m., train NP-01 departed Bonner Springs at milepost (MP) 18 and continued westward to Soldier Creek at MP 76 without incident.

[1] The events in this narrative are reconstructed using data from computer-aided dispatching (CAD) records and testimony from UP train crews and dispatchers. All times are central daylight time.

Meanwhile, train ME-29, consisting of 5 diesel locomotive units and 38 loaded cars, left Marysville, Kansas, about 12:30 a.m. on July 2, and proceeded eastbound without incident toward the Kenefick siding. Eight cars in the consist were flatcars carrying truck trailers, or TOFCs,[2] with containers of hazardous materials.

According to the Marysville Subdivision train dispatcher, he routed eastbound train ME-29 to move on the main track because it was a higher priority train than train NP-01. He routed westbound train NP-01 into the Kenefick siding and had a stop signal displayed at the west end of the siding. Before reaching the siding, train NP-01 passed two intermediate signals, which displayed the aspects shown in figure 2.

Both trains were equipped with Automatic Cab Signal (ACS) and Automatic Train Stop (ATS). Whenever the lead locomotive passed a more restrictive wayside signal aspect, a signal was displayed, and an audible alarm sounded in the cab, which the engineer was required to acknowledge within 8 seconds. Should the engineer not respond to the alarm, an automatic (penalty) application of the train brakes would occur. Additional information about ACS appears in the *Train Information* section of this report. Figure 2 also lists the cab indications that would have been displayed in the lead locomotive as it passed the mainline wayside signals after Soldier Creek.

As train NP-01 passed the intermediate signals at MP 78.3 and MP 80.7, no penalty application of the train brakes occurred. CAD records indicate that train NP-01 passed the east control point (CP) at the Kenefick siding signal about 2:05 a.m. and was completely in the siding and off the main track about 2:10 a.m.

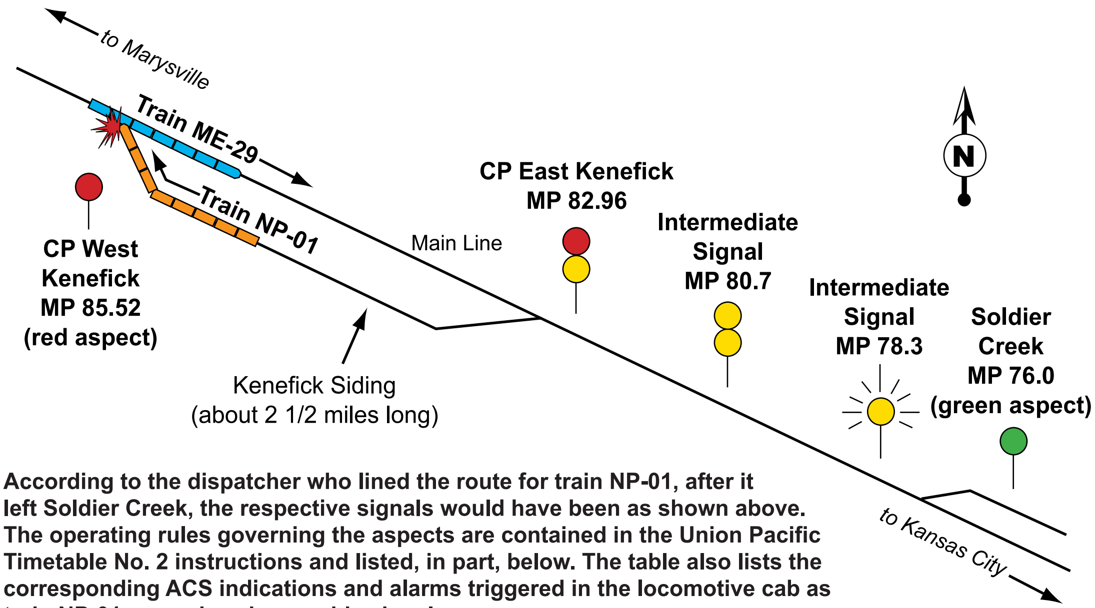
In recounting the events of the accident to Safety Board investigators, the NP-01 conductor testified that he observed the signal at West Menoken (Soldier Creek).[3] He initially said the Soldier Creek wayside signal was yellow over yellow; later in the interview, he said that it was a green signal. The NP-01 conductor subsequently stated that on the night of the accident, he was having a "slight stomach problem." He said that when the train approached the Soldier Creek signal, "I was on my way down to the bathroom," in the nose of the locomotive. He said that when he entered the lavatory, the speed of the train was "no more than 20 [mph] and probably about 15 [mph]." He remained in the lavatory while the train traversed the entire length of the siding, a distance of about 2½ miles.

The conductor said that the NP-01 engineer did not complain of feeling tired or ill and appeared "normal" during the trip. He said that he did not see him doze or go to sleep from the time they went on duty until he (the conductor) went into the lavatory.

The conductor stated that he was coming out of the lavatory when he heard what he thought was an "emergency application of the exhaust valve." He said about 3 to 4 seconds elapsed and then he yelled, "what happened." He said that the engineer replied,

[2] TOFC is an acronym for "trailer on flatcar" intermodal service.

[3] The milepost area now known as Soldier Creek was formerly called West Menoken.



According to the dispatcher who lined the route for train NP-01, after it left Soldier Creek, the respective signals would have been as shown above. The operating rules governing the aspects are contained in the Union Pacific Timetable No. 2 instructions and listed, in part, below. The table also lists the corresponding ACS indications and alarms triggered in the locomotive cab as train NP-01 passed each way-side signal.

Signal at CP East Kenefick	Intermediate Signal at MP 80.7	Intermediate Signal at MP 78.3
Name / Aspect	**Name / Aspect**	**Name / Aspects**
Diverging Approach — Red over yellow seachlight-type signal	*Approach Medium* — Double yellow seachlight-type signal	*Approach Limited* — Flashing single yellow searchlight-type signal
Timetable No. 2 Instructions	**Timetable No. 2 Instructions**	**Timetable No. 2 Instructions**
Proceed on diverging route at prescribed speed through turnout prepared to stop before any part of train or engine passes the next signal.	Proceed. Speed passing next signal must not exceed 30 mph.	Proceed. Speed passing next signal must not exceed 40 mph unless it can be plainly seen that ...the next signal displays *Clear, Approach Limited,* or *Approach Limited Passenger.*
ACS System	**ACS System**	**ACS System**
Approach — *Yellow*	*Approach* — *Yellow*	*Approach Limited* — *Yellow over green*
Cab signal continues to display a yellow aspect. No audible alarm sounds.	Cab signal drops from yellow over green to yellow, and audible alarm indicates a more restrictive cab signal.	Cab signal in locomotive drops from green to yellow over green, and audible alarm indicates a more restrictive signal.

Figure 2. Wayside signals and locomotive cab signals for train NP-01 from Soldier Creek to the entry of the Kenefick siding.

"I can't get it stopped." The conductor said that about 2 seconds later, when he was about halfway out of the stairwell from the lavatory, he felt the initial impact and the front of the engine collapsed on the engineer's side. He further stated:

> When I untangled myself between what was left of the refrigerator and the seat, he [the engineer] was pinned behind the control cabinet….his one foot was caught between the control panel, back wall, and [a] hole in the floor where a truck had either ruptured the floor or whatever… I tried to pick him up two or three times. I was throwing stuff everywhere trying to get him out of there….

In his account of the events preceding the collision, the ME-29 train engineer stated that he was approaching the Kenefick siding at a speed of about 70 mph when he observed a westbound train (NP-01) with its headlight on bright and its ditch lights illuminated about 3 miles away. The engineer stated that he and the ME-29 conductor tried several times to radio the on-coming train's crew to ask them to dim their lights. He said that they never received a response; however, he was not too concerned because the wayside signal that he was operating under was displaying a green, or *clear*, indication and the cab signal within his operating compartment unit was also displaying a *clear* indication. As a precaution, he switched the train's ditch lights on and off and flashed the high beam of the train's headlight several times. In accordance with UP operating procedures, when he was about ¾ of a mile from a private road crossing, he began sounded the train's horn for several seconds.

The ME-29 engineer said he was relieved when shortly thereafter the oncoming train's headlight dimmed and its ditch lights were turned off. He said he continued moving[4] and as the lead locomotive of the westbound train (NP-01) was passing on the siding, he looked over into the cab but could not see anyone because of the low cab lighting. He said that the speed of the passing train was "minimal, as though he [the NP-01 engineer] was trying to get stopped or [was] coasting to a stop…." The ME-29 conductor also said that train NP-01 was moving slowly.

The ME-29 engineer said that as the westbound train passed, he turned around and observed that it had a red, or *stop,* signal at the end of the siding. He said that shortly thereafter, his train (ME-29) went into emergency braking.

The collision occurred at UP MP 85.5, where the main line and the siding merge. The lead locomotive of train NP-01 struck the sixth freight car of train ME-29, resulting in the derailment of 15 cars from train ME-29 and 2 locomotives and 3 cars from NP-01 (figure 3). A fire erupted on train ME-29, engulfing the derailed cars and locomotives of both trains.

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[4] Event recorder data indicate that train ME-29 was traveling about 68 mph.

Figure 3. Accident site (looking east). Unit facing camera is the lead locomotive of westbound train NP-01.

After the collision, the engineer on train ME-29 said that he pushed the emergency call button on the locomotive radio several times but did not immediately receive a response from the dispatcher in Omaha, Nebraska. He then used his cellular telephone to report the collision to a local UP supervisor at 2:23 a.m. He said that immediately after he finished his call with the supervisor, the train dispatcher answered his emergency radio call at 2:24 a.m.

At 2:41 a.m., the Shawnee County Sheriff's Department (SCSD) dispatcher received a 911 call from a local resident reporting the derailment, whereupon the SCSD dispatched six units to the accident site. At 2:44 a.m., the SCSD requested fire and emergency medical services go to the accident. At 2:48 a.m., the SCSD received a call about the accident from the UP.

The first fire unit arrived on the accident site at 2:51 a.m. When responders initially arrived on scene, they noted that several trailers on the derailed cars were marked as containing hazardous materials. Not knowing whether any hazardous materials were involved in the fire, the responders evacuated about 1,500 people from the immediate area as a precaution. (Additional information about the response effort appears in the *Survival Factors* section of this report.)

Injuries

Table 1 is based on the injury criteria of the International Civil Aviation Organization, which the Safety Board uses in accident reports for all transportation modes.

Table 1. Injuries sustained in Delia, Kansas, accident

Injury Type	Train MKSNP-01	Train ZSEME-29	Total
Fatal	1	0	1
Serious	0	0	0
Minor	1	0	1
None	0	2	2
Total	2	2	4

49 *Code of Federal Regulations* (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."

Damages

The UP provided the damage estimates shown in table 2.

Table 2. Damages sustained in the Delia, Kansas, accident

Locomotives and Cars	$ 2,174,714
Lading	2,200,000
Track	641,000
Wreckage Cleanup	125,000
Total	$5,140,714

Wreckage

The five locomotive units of train ME-29 were not damaged in the accident. The locomotive units of train NP-01 sustained the structural impact damage described below and were ultimately destroyed by fire.

Locomotive UP 3616

The control stand was displaced rearward 3 feet (figure 4). The right side wall at sill level showed extensive intrusion damage and was separated from the sill. The upper half of the right rear control compartment door was displaced inward and jammed in the door frame. The left front door was open. All window glazing was broken out of the

Figure 4. Unit UP 3616, the lead locomotive of train NP-01

window frames in the control compartment. The fuel tank was still attached to the underside of the sill; however, the tank's front wall was crushed rearward and was distorted, gouged, and holed on its left side and its underside.

Locomotive SP 7519

The rear portion of the control compartment was completely torn from the superstructure (figure 5). The fuel tank was still attached to the underside of the sill; however, the tank had sustained extensive longitudinal tearing, had been breached, and was holed and creased.

Personnel Information

Safety Board investigators reviewed the personnel files and work records of the two train crews and the dispatcher. Records showed that the train crews were qualified on the physical characteristics of the Marysville subdivision, which included the accident area. Marysville subdivision supervisors had conducted a combined total of 226 efficiency tests of the four crewmembers and recorded four failures between July 1996 and June 1997. The ME-29 engineer had failed to sound the locomotive horn properly at a crossing on April 3, 1997. The NP-01 conductor had been cited for three efficiency test failures, including the failure to comply with an operating rule upon entering a main track at a

Figure 5. Unit SP 7519, the second locomotive of train NP-01

hand-operated switch on July 15, 1996, the failure to have adequate hearing protection on July 25, 1996; and the failure to inspect a train while in a siding on August 26, 1996. The NP-01 engineer, the ME-29 conductor, and the dispatcher had no efficiency test failures.

Train NP-01 Engineer

General. The NP-01 engineer was hired by the UP as a switchman (brakeman) on July 6, 1978. He was promoted to conductor on October 13, 1987, and to locomotive engineer on November 26, 1990. UP records indicate that he had most recently passed an operating rules test on February 21, 1996, and that he had been examined and had received a passing score on various aspects of railroad operations, including track warrants, bulletins, air brakes, signals, and mechanical systems. Before being promoted to engineer, he had received 3 weeks student-engineer training. He also had received company training in fuel conservation, winter safety, locomotive daily inspection, hazardous materials, and distributed power.

72-hour History. The NP-01 engineer had been on vacation for 17 days before reporting for duty the evening of July 1, 1997. His wife said that during his vacation, he retired each evening between 9 p.m. and midnight and normally awoke the following morning between 5 a.m. and 7 a.m. She said that he typically would get from 5 to 9 hours of sleep per rest period and that, regardless of what time he had retired the previous evening, he typically did not sleep during daylight. She recalled that he retired between 9:30 p.m. and 10 p.m. on June 30 and awoke the next morning about 8 a.m. He remained awake until he left for work after receiving a 7 p.m. call to report for work at 8:30 p.m. Based on information obtained from his spouse, the NP-01 engineer had been on duty for 5 hours and 45 minutes and had been continuously awake for about 18 hours and 15 minutes at the time of the accident.

Medical History. UP records indicate that the engineer underwent a company hearing and vision test on November 13, 1995, as part of the UP locomotive engineer recertification program. He successfully passed the hearing portion of the test, but not the vision requirements. His right eye was rated 20/20, and his left eye 20/70. The UP indicated in a November 17, 1995, letter to him that he was required to provide medical documentation certifying that his vision was at least 20/40 in each eye. In December 1995, the engineer had eye surgery at Medical-Surgical Eye Care in Kansas City, Kansas. UP records contain a December 29, 1995, letter from Medical-Surgical Eye Care stating that the engineer's vision rating in his left eye was correctable to 20/20. Records show that the UP physically qualified him for duty as a locomotive engineer on January 2, 1996.

Train NP-01 Conductor

General. The conductor was hired by the UP as a switchman (brakeman) on May 11, 1970. On May 20, 1974, he was promoted to conductor. UP records indicate that the conductor most recently passed the operating rules test for his position on October 19, 1995, and that he had received operational training in fire extinguisher use and forms management and awareness training about drugs, hazardous materials, and "mental vacations," that is, how lapses in attention to duties can result in rail accidents.

72-hour History. The NP-01 conductor stated that on Sunday, June 29, he went to bed about 9 a.m. and slept until about 3 p.m. He said that he was off the following 2 days and that during those days, he retired each evening between 10 p.m. and 10:30 p.m. and awoke the following mornings between 5 a.m. and 6 a.m. He said that on the afternoon of Tuesday, July 1, he received a call informing him that he would be working that evening. He stated that he napped from about 2:30 p.m. or 3 p.m. until 4:30 p.m. or 5 p.m. After waking up, he went on duty at 8:30 p.m. At the time of the accident, he had been awake between 9 and 10 hours and had been on duty about 5 hours and 45 minutes.

Medical History. UP records show that the NP-01 conductor most recently underwent a physical examination on January 26, 1993. On the accompanying medical form to the examination, he indicated that he took medication for high blood pressure and diabetes. The medical examiner determined that he was medically qualified to perform his duties as a conductor.

The conductor advised Safety Board investigators that he had discovered that he had Type II diabetes (non-insulin-dependent diabetes) in 1988 and that the UP had been aware that he had the disease since that time. He said that he had his blood sugar level checked every 30 days by his physician. He said that to control the diabetes, he took two medications, 10 milligrams of Glucotrol[5] once a day in the morning and 5 milligrams of

Glucophage[6] twice a day (morning and evening). He said that he also discovered he had hypertension in 1988 and that he took 10 milligrams of Monibril[7] each day to control this disease. The conductor indicated that he had never experienced any adverse effects from taking the medications, that both the diabetes and hypertension were under control, and that neither condition had caused him any problems in his work as a conductor.

Train ME-29 Engineer

General. The engineer was hired by the UP as a switchman (brakeman) on July 10, 1984. He was promoted to engineer on July 29, 1988. UP records indicate that the engineer most recently had passed the operating rules test for his position on March 10, 1997, and that he had received operational or awareness training in hazardous materials, mental vacations, distributed power, fuel conservation, employee assistance–peer support, and incident reports.

72-hour History. The engineer was called to work at 12:50 a.m. on Sunday, June 29. His train departed at 3:40 a.m., and he went off duty at 11:20 a.m. He said that he slept from about 2:00 p.m. until about 7:00 p.m. He said that he was called for duty at 7:20 p.m. and departed on his train at 9:30 p.m. He completed the trip at 6 a.m. the following morning, Monday, June 30, and went off duty at 6:50 a.m. He said that he was off duty for 16 hours and 5 minutes, during which he slept 8 hours. He was called for duty at 11 p.m. on June 30 and departed on his train at 1 a.m. on July 1. He arrived at his destination at 10:30 a.m. and went off duty at 11:15 a.m. He was off duty for 12 hours and 30 minutes, of which he slept 8 hours. At 11:45 p.m. on July 1, he was called to report to duty. His train departed about 12:30 a.m. on Wednesday, July 2. At the time of the accident, he had been on duty for about 2 hours and 30 minutes.

Train ME-29 Conductor

General. The ME-29 conductor was hired by the UP as a switchman (brakeman) on September 1, 1975. He was promoted to yardmaster on July 1, 1984, and to his present position, conductor, on May 1, 1992. The UP records show that he had most recently passed the operating rules test for his position on January 10, 1996, and that he had received training in drug awareness and hostling[8] qualifications for switchmen. He testified that he had attended 2 weeks of switchman training when he was hired by the railroad.

72-hour History. On Sunday, June 29, the ME-29 conductor arose at 8:30 a.m. and remained awake until he went to bed at 6:30 p.m. He rested and slept until about 10:30 p.m. He traveled to an away terminal in Topeka, Kansas, where he went on duty at 11:59 p.m. The following morning, Monday, June 30, he went off duty at Topeka at 7:59 a.m. He

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[5] An oral blood-glucose-lowering drug.

[6] An oral antihyperglycemic drug used to manage non-insulin-dependent diabetes mellitus.

[7] The investigation disclosed that the conductor was referring to Monopril, an antihypertensive angiotensin-converting enzyme inhibitor used to treat high blood pressure and congestive heart failure.

[8] The act of moving a locomotive around between runs, typically within the rail yard.

then drove to his home in Kansas City, Missouri, where he slept from 9:30 a.m. until 2:30 p.m. After he awoke, he went shopping and then had dinner with his family. He returned to Topeka at 7:00 p.m. and retired at 8:30 p.m. He awoke at 10 p.m. and worked from 11:00 p.m. until 11:15 a.m. on July 1. He slept from 11:30 a.m. until 5:00 p.m. After he awoke, he ate and conversed with railroad personnel in the dormitory until 7 p.m. He slept from 7:00 p.m. until about 10:15 p.m. He reported for duty at 11:45 p.m. and worked until the accident. At the time of the accident, the ME-29 conductor had been awake for about 4 hours and on duty for 2 hours and 30 minutes.

Train Dispatcher

The train dispatcher was hired as a clerk in 1985 by the Missouri-Kansas Texas Railroad Company, which later merged with the UP. In 1989, he began dispatching. He had last attended a rules class in 1997. He had been off duty for more than 15 hours before reporting for duty at 11:00 p.m. on July 1.

Train Information

Train NP-01

Train NP-01, comprising 68 cars and two locomotives (UP 3616 and SP 7519), was made ready at 7:50 p.m. on July 1, 1997, at UP's 18th Street Yard in Kansas City. Mechanical personnel conducted a yard plant air test, and the train crew checked the two-way end-of-train device before the train departed Kansas City at 10:10 p.m.

The train stopped at Bonner Springs, Kansas, where the crew added a block of 22 loaded auto-rack cars behind the locomotives. The NP-01 conductor said that after the additional cars were coupled together and their air brake hoses connected, he inspected the newly added cars and performed an air brake set and release test. The train then consisted of two diesel-electric locomotives pulling 39 loaded and 51 empty cars. Its trailing tonnage was 5,347, and it was 6,445 feet long.

Train ME-29

Train ME-29 originated in Seattle, Washington, on June 29, 1997, and was destined for Memphis, Tennessee. The train traveled through Oregon, Idaho, Wyoming, and Nebraska before entering Kansas. It had received a Federal Railroad Administration (FRA) 1,000-mile inspection at Pocatello, Idaho, and at North Platte, Nebraska. Marysville was its last crew change point before the accident. Train ME-29 departed Marysville at 12:30 a.m. on July 2, 1997, and proceeded without incident to the Kenefick siding, about 60 miles away.

At the time of the accident, train ME-29 consisted of 5 locomotive units (UP 6129, UP 9241, SP 8599, UP 3696, and UP 6010) and 38 loaded cars. Its trailing tonnage was 3,925 and it was 6,034 feet long. Most of the cars were articulated deep-well container-on-flat-cars (COFCs) or spine TOFCs with three to five platforms. The train also had 89-foot-long flat cars carrying one or two trailers or containers or both.

Automatic Cab Signal Systems

As mentioned earlier, both trains were equipped with ACS, an electronic display system that works in concert with the ATS. On UP trains, the ACS signal display typically is mounted above the control panel between the forward cab windows of the locomotive so that the signal is clearly visible by all crewmembers in the operating cab. The ACS illuminates one of four signals (figure 6), which change only when the locomotive passes a wayside signal indicating a different level of restriction. Whenever the wayside signal has a less restrictive indication, only the ACS light display changes. Whenever the wayside signal has a more restrictive indication, the ACS light display changes and the device activates an alarm. The alarm continues to sound until the engineer pushes a spring-action lever that, on UP trains, is on the front right of the control stand. If the locomotive engineer fails to acknowledge the ACS alarm within 8 seconds, a full service penalty brake application of the train airbrake system results.

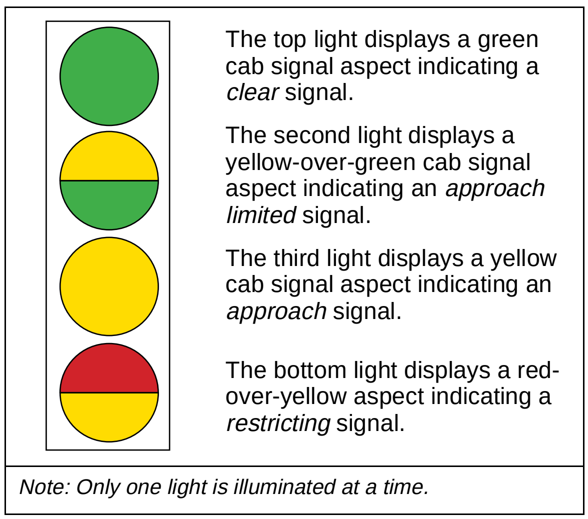

Figure 6. Order and indication of the automatic cab signal system lights

Other Industry Safety Features for Trains

Neither of the accident trains was equipped with automatic speed control, which triggers a penalty brake application to reduce train speed when the train operator passes a wayside signal faster than the allowable speed indicated by the aspect.

The locomotive cabs of train NP-01 and train ME-29 were not equipped with an alerter, an electronic device that monitors the movement of the engineer. A lack of a significant movement, such as touching a certain metal object or making a control manipulation, within a specified time results in the alerter generating an audio alarm, a visual alarm, or both, which, if not acknowledged by the engineer, result in the locomotive being brought to a gradual, controlled stop. In most cases, the alerter time interval varies with the speed of the locomotive; the faster a train's speed, the shorter the time interval during which the engineer must move.

Postaccident Examinations

Teams comprising representatives from the Safety Board, the FRA, and the UP performed equipment inspections and air brake tests on the undamaged vehicles. Investigators inspected and measured all undamaged cars for brake shoe wear and piston travel; they determined that no brake shoes were condemnable and that the type and number of minor defects were acceptable under FRA standards.

Investigators conducted an initial terminal air brake test in accordance with 49 CFR 232.12 on all cars and noted no deficiencies. All wheels and running gear were serviceable. Locomotive electricians removed the ATS and ACS equipment from the NP-01 lead locomotive (UP 3616) for testing at UP's mechanical facility in Sedalia, Missouri. The tests, which were monitored by Safety Board investigators, indicated that the systems operated as designed.

Hazardous Materials

One of the trailers (RDWZ 221251) involved in the fire carried packages containing 18 spent generators that produced a radioisotope used in nuclear diagnostic medicine.[9] Mallinckrodt Medical/Airport Drayage Company of Seattle, Washington, had contracted Roadway Express, Inc., to transport the spent generators to Mallinckrodt's Maryland Heights, Missouri, plant for recycling. Roadway, in turn, had contracted UP to transport the trailer (as a TOFC) from Portland. Eight packaged generators were shipped as a Radioactive Yellow II material, and 10 packaged generators were shipped as a Radioactive White I material.[10]

Tests at the accident site showed that the combined radioactive exposure was well below the exposure level for public concern.[11] Radiation surveys of the burned rail cars showed that the floor of one car had low radiation levels which, tests showed, were indistinguishable from local background levels.[12] (For a list of the hazardous-materials-carrying truck trailers that were involved in the derailment and a detailed description of their contents and the contents' status, see appendix B.)

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[9] Each generator contained a column of molybdenum 99 (Mo99) chemically bonded to an inert material shielded with lead. The radioisotope, Tc99m, is a byproduct of Mo99 decay. Hospital staff collect the Tc99m by removing it from the Mo99 column with a saline solution.

[10] Three shipping categories are used in transporting hazardous materials; Radioactive White I is the lowest, and Radioactive Yellow III is the highest. The shipping categories are based on the surface radiation level of the package and the transport index, or TI number, which is placed on the package label by the shipper to designate the degree of control to be exercised by the carrier during transportation.

[11] Based on Kansas Department of Health and Environment standards.

[12] Local background levels ranged from 30 to 50 microroentgens per hour.

Track and Signal Information

Track

The Marysville Subdivision of the Kansas City Service Unit at MP 85.47 near Kenefick had two track structures, a main track and a siding track, which were owned, inspected, and maintained by the UP. The main track had a maximum allowable operating speed of 70 mph, designating it as FRA-class-5 track. The siding track had a maximum allowable operating speed of 30 mph, designating it as FRA-class-3 track. In 1996, traffic density averaged 60 to 75 trains per day, for a total of 155.1 million gross tons.

The two tracks were parallel and spaced at 15.67 foot track centers. The siding track was 12,729 feet long between clearance points. The distance between the eastbound and the westbound switch points on the siding track was 13,495 feet. The tracks were oriented geographically in a northwesterly to southeasterly direction and by timetable in a west and east direction. The MP numbering decreased in an eastward timetable direction.

The track gradient beginning at a point about 1.76 miles east of the siding was as follows for westward movement: between MP 81.2 and MP 81.6, level grade; between MP 81.6 and MP 84.4, a 0.6-percent ascending grade; between MP 84.4 and MP 85.3, level grade; and between MP 85.3 and MP 86.3, a 0.6-percent descending grade.

Two curves were located between MP 81.0 and MP 87.0. For a westward movement, a 1-degree, 59.8 minute-left-hand curve was between MP 81.3 and MP 81.55, and a 1-degree, 33.3-minute right-hand curve was between MP 83.9 and MP 84.2.

The switch near the area of the collision was a dual-controlled, power-operated machine that could be operated by hand at the site or remotely by a UP dispatcher at the Harriman Dispatching Center in Omaha.

Safety Board investigators visually inspected the main and siding track structure and found no anomalous conditions other than the damage caused by the collision and subsequent derailment. Investigators also reviewed the UP track and switch inspection records for May 1, 1997, to July 1, 1997, and found that company maintenance crews had inspected both the main track and the siding track more frequently than required by the UP and that they had immediately taken proper corrective action when track defects were noted. The most recent inspection of the switches at the siding was on June 29, 1997. No deviations were listed on the inspection report.

Signal

A Traffic Control System (TCS) wayside signal system was in effect from East Topeka to Gibbon Junction on the Marysville Subdivision. The TCS signal system had an ATS overlay supplemented with an ACS system between MP 72.9 at Soldier Creek and MP 147.8 at East Marysville, a distance of 74.9 miles, and between MP 150.5 at West Marysville and MP 287.8 at Gibbon Junction, a distance of 137.3 miles. The siding at Kenefick between MP 82.9 and MP 85.5 was controlled by these signal systems.

The wayside signals were Union Switch and Signal H-2 search-light models with M-23 power-operated, dual-controlled model switch machines and DC noncoded track and line circuits. The DC track circuits had superimposed AC coded circuits for operating ACS-ATS systems onboard locomotive units so equipped.

After the accident, UP signal department personnel arrived at the Kenefick siding and had secured the signal cabin at the east end by 4:30 a.m.; they had secured the signal cabin at the west end of the siding and the approach signal at MP 87.2 by 7:30 a.m. These tasks were completed in accordance with Rule 3.1.2 of the UP's *Signal Tests and Standards* emergency procedures.

UP signal personnel conducted postaccident testing of the signal system, which was monitored by Safety Board investigators, to determine whether the wayside signals and switches were functioning properly and relaying correct operating information to train crews. The protocol conformed to examination procedures contained in 49 CFR and in the UP *Signal Maintenance, Inspection Test, and Standard Instructions* manual and included the tests for the following: switch obstruction, point detector, shunt fouling, indication locking, time and route locking, grounding, and searchlight mechanism operation. Tests of the wayside signal system and its associated circuitry indicated that the system operated as designed. The UP's signal department also provided records of past UP signal tests, which indicate no exceptions noted for the wayside signals in the accident area. (Appendix C shows the sequence of signal events on the day of the accident.)

Operations Information

General

Train movement over this territory is governed by the *General Code of Operating Rules* (GCOR), third edition, effective April 10, 1994. Excerpts from the GCOR related to the general duties of engineers and conductors are shown in figure 7.

At the time of the accident, UP timetable No. 2, dated October 29, 1995, was in effect. The TCS is under the direction of the Marysville Subdivision train dispatcher at the Harriman Dispatching Center.

GCOR Rule 5.16, "Observe and Call Signals," stipulates that crewmembers in the engine control compartment must announce to each other the signals as they become visible or audible and announce any aspect change until the train passes the signal. Rule 5.16 further states:

> If the signal is not complied with promptly, other crewmembers must remind the engineer and/or conductor of the rule requirement. If the crewmembers receive no response or if the engineer is unable to respond, they must immediately take action to ensure safety, using the emergency brake valve to stop the train, if necessary.

The UP operating rules do not require the engineer to call signals over the radio when he is alone in the locomotive cab.

Rule 1.47 Duties of Trainmen and Enginemen

The conductor and the engineer are responsible for the safety and protection of their train and observance of the rules. If any conditions are not covered by the rules, they must take every precaution for protection.

Conductor Responsibilities

The conductor supervises the operation and administration of the train.…All persons employed on the train must obey the conductor's instructions, unless the instructions endanger the train's safety or violate the rules. If any doubts arise concerning the authority for proceeding or safety, the conductor must consult with the engineer who will be equally responsible for the safety and proper handling of the train.

The conductor must advise the engineer and train dispatcher of any restriction placed on equipment being handled.

Freight conductors are responsible for the freight carried by their train. They are also responsible for ensuring that the freight is delivered with any accompanying documents to its destination or terminals. Freight conductors must maintain required records.

Engineer Responsibilities

The engineer is responsible for safely and efficiently operating the engine. Crew members must obey the engineer's instructions that concern operating the engine. A student engineer or other qualified employee may operate the engine under close supervision of the engineer. Any employee that operates an engine must have a current certificate in his possession.

The engineer must check with the conductor to determine if any cars or units in the train require special handling.

Figure 7. Excerpts from the *GCOR*

UP Fatigue Program

1990 Mailing. According to the UP General Director for Safety, the carrier contracted SynchroTech of Lincoln, Nebraska, to conduct a study of UP employees and managers in all operating crafts to obtain input about work schedules, rest, lifestyles, diet, exercise, and alertness. SynchroTech prepared *The Railroader's Handbook: A Personal Health & Lifestyle Guide for Professional Railroaders* (hereafter referred to as the handbook), and a video on fatigue-related subjects.

In September 1990, the UP mailed an explanatory letter along with the handbook and video to the homes of UP's 14,000 train and engine service employees and 3,000 mechanical service employees. The carrier also sent the material to the Safety Board, the Association of American Railroads (AAR), and several other railroad companies.

After the initial employee mailing in 1990, the UP sent the fatigue video to all company divisions for inclusion in their libraries. Individuals hired after September 1990 were to be given the fatigue handbook at the same time they were given a UP rulebook and were encouraged to view the video in the library.

According to UP officials, the company did not document which employees received a copy of the video and handbook in September 1990. Likewise, it did not have a process for determining or documenting whether employees hired after 1990 actually read the handbook or viewed the video.

Program Expansion. Following the Synchrotech project, the UP began a number of initiatives to improve its fatigue program. In 1992, the UP hired a contractor to expand the carrier's fatigue educational effort. The contractor assisted with the design and implementation of the 1994 Sleepwell Pilot, which demonstrated that fatigue could be positively affected through behavioral change model.

Postaccident Actions. In July 1997, the UP established a Senior Level Team (SLT), led by the Executive Vice President of Operations, which meets at least once monthly to define the details and work plan of the company's fatigue program.

After a representative from the UP's Health Services Department and the SLT attended a fatigue training module developed by the National Aeronautics and Space Administration's (NASA's) Ames Research Center, on July 29, 1997, the UP conducted an educational seminar based on the NASA program. According to UP officials, the carrier plans to use information from the NASA-based module along with information on additional countermeasures in future educational sessions.

In September 1997, based on the SLT's recommendation, the UP established the position of Director of Alertness Management, whose purpose is to manage projects addressing the following:

- Education;
- Crew scheduling and collective bargaining issues;
- Manager issues;
- Technology;
- Napping strategies; and
- Healthy sleep initiatives.

Additionally, the Director of Alertness Management is responsible for obtaining and overseeing outside consultants. In December 1997, the UP contracted with Alertness Solutions to provide the carrier with the needed expertise to develop a comprehensive, integrated, and systematic program to address fatigue. The program plan that was developed for 1998 appears in appendix D. Company officials indicate that the carrier plans to make available to employees a fatigue countermeasures book, as well as a revised Health Risk Appraisal (HRA). The new HRA will offer employees the opportunity to work one-on-one with a counselor. Employees wishing assistance will be offered individual counseling sessions, independent study guides, and periodic mailings.

UP officials stated that carrier representatives have attended most, if not all, of the fatigue management meetings for the transportation industry in the last 3 years, including the March 1998 public hearing that the Safety Board convened following several UP accidents.

Accident Crews' Testimony

The conductors of the trains involved in this accident recalled that they had received the fatigue material. The ME-29 engineer stated that he never had received the information and was not aware of a company-sponsored fatigue management program.

The deceased engineer's spouse could not recall either her or her husband receiving any fatigue-related material from the UP.

Each surviving crewmember reported that he was awake and alert from the time he went on duty up to and including the accident. The crewmen said that they did not feel overworked on the evening or the morning of the accident. The NP-01 conductor said that he did not see the engineer fall asleep or doze during any portion of the trip. The NP-01 conductor reported that the workload was "nothing out of the ordinary" and added that the engineer of his train did not appear to be distracted or preoccupied up to and during the accident.

Although the ME-29 engineer said he was not tired or stressed on the morning of the accident, he also stated that he considered fatigue a problem on the railroad. He said that the rest pattern that he had learned to live with is "a very difficult situation for me and I believe most engineers." He indicated that the company had not "offered me any type of training or any type of in-service on how to manage my stress or fatigue" and stated that a fatigue management program was needed at the UP.

Meteorological Information

Weather observations from the Topeka airport, which is about 19 nautical miles southeast of Delia, reported the following conditions at 1:56 a.m.: temperature, 80° F; winds, 4 knots; skies, partly cloudy; and visibility, 10 miles. At 2:56 a.m., the temperature was 78° F; winds, calm; skies, clear; and visibility, 10 miles.

Medical and Pathological Information

Fatalities

The Shawnee County coroner stated that when he arrived on scene at 8:15 a.m. and entered the control compartment of locomotive 3616, he observed the deceased NP-01 engineer lying on his back forward of the control stand and laterally across the metal beams supporting the cab floor. The Shawnee County coroner's autopsy findings indicate that the engineer had extensive thermal destruction and soot in his upper airways.

The NP-01 conductor sustained multiple contusions. He was taken to St. Francis Hospital in Topeka, where he was treated in the emergency room and released.

The engineer and conductor of train ME 29 were not injured.

Toxicological Testing

Pursuant to FRA postaccident toxicological testing requirements contained in 49 CFR 219 Subpart C, surviving crewmembers provided specimens that were tested by the FRA for the presence of alcohol and drugs. The UP dispatcher who was on duty at the time of the accident also provided specimens for testing. All personnel tested negative for alcohol and illegal drugs. The fatally injured engineer's toxicological tests were also negative for alcohol and drugs.

Survival Factors

Emergency Response

As mentioned earlier, the SCSD dispatcher was notified of the accident at 2:41 a.m.; he immediately dispatched six SCSD units to the accident scene. At 2:44 a.m., the SCSD requested assistance from the American Medical Response (AMR), a Topeka-based private ambulance service that contracts with volunteer fire and rescue departments to provide, among other services, dispatch and emergency medical services. The AMR dispatched two ambulance units at 2:45 a.m. and then dispatched by pager and by radio tone the Rossville Volunteer Fire Department at 2:46 a.m. In all, one fire chief, one ambulance, two engines, one tanker, one brush truck, and one rescue truck responded to the scene. According to the AMR, the first fire unit arrived on scene at 2:51 a.m.

When the Rossville fire chief could not readily determine whether the contents of the trailers carrying hazardous materials were involved in the fire, the SCSD began the evacuation of about 1,500 residents from Rossville and the rural area surrounding the accident site at 3:00 a.m. The Rossville fire chief then called for neighboring counties to provide mutual aid. At 3:30 a.m., the Rossville fire chief established a field command post and staging area at 86th Street and Caper Road. At the same time, the chairman of the Shawnee County Commissioners issued an evacuation declaration, which, in turn, initiated the Shawnee County disaster plan.

Once responders determined that the spilled radioactive materials did not present a public threat, the Rossville evacuees were notified at 8:49 a.m. that the evacuation was canceled. By 9:15 a.m., most evacuees had returned to their residences. The activation of the county disaster plan was subsequently terminated at noon.

Disaster Preparedness

The stated purpose of Shawnee County's disaster plan is to prevent and minimize injury and damage, reduce exposure of county residents to a disaster, mobilize support agencies, provide prompt and effective response to a disaster, and provide for return to normalcy.

Before this accident, Shawnee County had last tested parts of its disaster plan on April 26, 1997, when it simulated a rural fire department responding to a hazardous materials incident involving one fatality and 17 injuries. Although the Rossville fire department, which is in Shawnee County, had not conducted drills with the UP, the carrier's representative had provided hazardous materials training for members of the Shawnee County emergency management agency and for other Shawnee County fire departments.

Tests and Research

On July 8, 1997, about the same time of day that the collision occurred, Safety Board investigators participated in a test to determine the sight distance and to examine the operation of the radio, wayside signals, and locomotive cab signals.

Train ME-29

Investigators tested the radio from train ME-29's lead locomotive (unit 6129) at several locations en route to the accident site and noted no exceptions. Testers stopped the locomotive at the accident site and pressed the emergency call button. In all tests, the dispatch center received the transmitted radio calls with no anomalies.

Train NP-01

Because the lead locomotive of train NP-01 was damaged in the collision, testers used a similar locomotive unit, UP 3696, to test the operation of the westbound train and the signal system. As the test locomotive proceeded westward from Soldier Creek (MP 76.0), the signal system and the cab signal system functioned as designed and as described by the dispatcher who routed train NP-01 (see figure 8).

Milepost	Wayside Signal Aspect (Indication)	Cab Signal Aspect (Indication)	Audible Alarm?	Actions
76.0 (Soldier Creek)	green (proceed)	green (proceed)	None	N/A
78.3	flashing yellow (approach limited)	changes to yellow-over-green (approach limited)	Yes	Test locomotive engineer acknowledges alarm
80.7	yellow-over-yellow (approach medium)	yellow (approach)	Yes	Test locomotive engineer acknowledges alarm
CP East Kenefick	red-over-yellow (diverging approach)	same as above	None	N/A
CP West Kenefick	red* (stop)	As the locomotive unit passes this wayside signal, the cab signal drops to red-over-yellow (restricting)	Yes	Test engineer purposely does not acknowledge alarm. About 7.5 seconds later, a full service penalty brake application of the locomotive brake system occurs and stops the locomotive unit.

*Measurements indicated that westward signal for the siding track was clearly visible from 7,453.15 feet.

Figure 8. Signal indications and alarms during postaccident tests

A-1 Charging Cut-Off Valve

Safety Board investigators examined the A-1 charging cut-off pilot valve from train NP-01's lead unit (UP 3616) to determine the position of the cut-off piston, an indication of whether the emergency braking occurred from the train operator moving the automatic brake handle to the emergency position (up position) or from a trainline separation or rupture initiating the emergency braking (down position). Investigators found the cut-off piston in the applied, or down, position.

Event Recorders

The event recorder of NP-01's lead unit, UP 3616, was destroyed by the collision and fire (see figure 9). The second unit was not required to be and was not equipped with an event recorder. UP officials printed out the recorded data from train ME-29's event recorders under the supervision of Safety Board investigators.

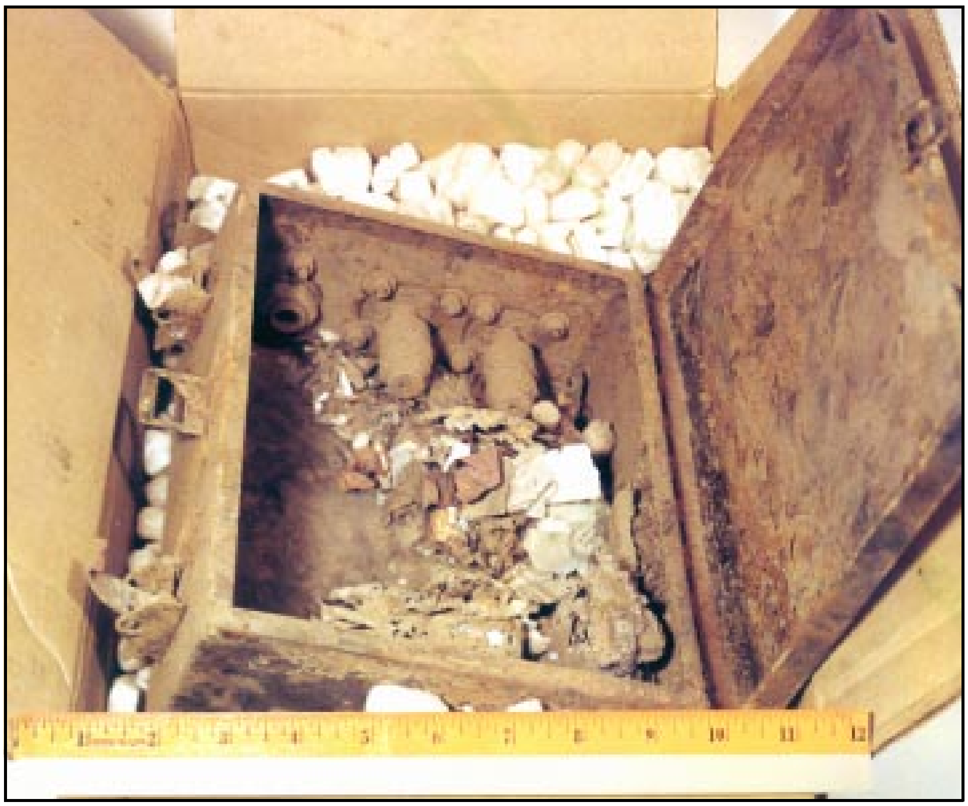

Figure 9. The event recorder from UP 3616, train NP-01's lead locomotive

Other Information

Past Safety Board Actions

Following its investigation of a February 16, 1996, accident in which a Maryland Rail Commuter (MARC) train collided with a National Railroad Passenger Corporation (Amtrak) passenger train near Silver Spring, Maryland, the Safety Board identified the need for train operating cabs to have voice recording devices, similar to the type installed in the cockpit of aircraft. In the Silver Spring accident, the Safety Board determined that the MARC engineer and traincrew failed to operate the train according to signal indications, colliding head-on with the Amtrak lead unit, which resulted in the deaths of 11 people, including all MARC train operating crewmembers, and in the injuries of 26 people in the derailment and subsequent fire.

In its report of the accident, the Safety Board observed that the cockpit voice recording had been a key tool in documenting the circumstances leading up to an accident and valuable in determining the cause of aviation accidents for more than 35 years. The Board noted that although current locomotive event recorders have great utility in providing mechanical response data, they cannot answer some questions about the crewmembers' knowledge and actions. In the case of the Silver Spring accident, the Safety Board stated that had a voice recording from the MARC train existed, investigators could have determined from the communications before the collision the factors that may have affected the MARC train operator's actions. The Safety Board, therefore, made the following recommendation to the FRA:

R-97-9

Amend 49 CFR, Part 229, to require the recording of train crewmembers' voice communications for exclusive use in accident investigations and with appropriate limitations on the public release of such recordings.

Analysis

General

Nothing in either the predeparture tests or the postaccident equipment inspection indicated any equipment failure, and neither crew had reported any problems while en route. Postaccident inspections and tests found no track defects or deviations from FRA track safety standards and identified no problems with the signal system.

The train dispatcher had 10 years of experience in his position and demonstrated sufficient knowledge of centralized traffic control procedures and dispatcher duties. Each train crewmember had received the necessary operational training and experience to competently perform his duties. Further, each member had passed UP physical and visual examinations and rules tests and had been observed and tested on stop signal and operational movements. Results of postaccident toxicological tests indicate that the dispatcher and the train crewmembers were not impaired by alcohol or drugs.

The Safety Board concludes that the train equipment, the track, and the signal system functioned as designed; the dispatcher and train crews were qualified, trained, and tested to properly perform their duties; and no UP employee tested as a result of this accident was impaired by alcohol or drugs.

Emergency responders, upon reviewing the train consist and noting that containers involved in the accident and fire carried hazardous materials, took appropriate precautionary measures for a hazardous materials incident. Surveys showed that the radioactive packages were well below the public exposure levels set by the Kansas Department of Health and Environment and that the few spots of low-level radioactivity on the floor of one rail car disappeared into the background radiation at distances greater than 2 feet. Therefore, the Safety Board concludes that the hazardous materials cargo did not cause or increase the severity of this accident.

Accident Analysis

Because the recorder in the lead locomotive of train NP-01 was destroyed in the collision and fire, the train's movement cannot be precisely determined. However, given the times of signal changes recorded at the dispatch center, the distances covered, and other factors, a reasonable account can be reconstructed.

After passing the green signal at Soldier Creek, the engineer of westbound train NP-01 passed two intermediate wayside signals that would have triggered alarms in the locomotive cab requiring a response by the engineer. Postaccident tests indicated that the ACS and ATS systems operated as designed; therefore, the engineer apparently did correctly acknowledge the ACS audible alarms as required during this portion of the trip; otherwise, an automatic (penalty) application of the train brakes would have occurred.

CAD records indicate that the almost 1 ¼-mile-long NP-01 train began entering the siding at CP East Kenefick about 2:05 a.m. and was completely in the siding and off the main track by 2:10 a.m. Based on the time that the train entered the siding and the time that circuit damage was recorded at the signal at the west end of the 2 ½-mile-long siding (2:15:23 a.m.), train NP-01 probably was traveling about 15 mph when it passed the red signal at MP 85.52 (West Kenefick). The train's failure to stop for the red signal would have resulted in the ACS cab signal dropping and the ACS alarm sounding, which, if not acknowledged by the engineer, would have resulted in an automatic (penalty) application of the train brakes. The position of the A-1 charging valve indicates that the engineer did not apply the brakes and that the they automatically activated as a result of a penalty application. However, the momentum of train NP-01 carried it forward, and it struck the side of eastbound train ME-29, which was operating on a *clear* signal.

Based on its investigation of this accident, the Safety Board identified issues in the following areas:

- NP-01 engineer's performance,
- UP's fatigue education program,
- crew resource management, and
- positive train separation (PTS) control systems.

The Safety Board also looked at other safety-related issues, such as alerters, event recorder crashworthiness, and voice recorders.

NP-01 Engineer's Performance

The Safety Board examined the performance of the NP-01 engineer in the context of information provided by the NP-01 conductor and the train ME-29 crew. The NP-01 conductor stated that on the night of the accident, the NP-01 engineer appeared normal and did not complain of feeling tired or ill. He said that he did not observe the engineer nod or go to sleep from the time they went on duty until the train was about 9 miles from the accident site, when he (the conductor) went into the lavatory, where he remained for about 20 minutes. The NP-01 conductor described the cab conditions as dark, except for a small light in the step well to the lavatory. He said that the train was operating about 15 to 20 mph when he left the operating cab.

The ME-29 engineer stated that as he was approaching the Kenefick siding he observed a westbound train (NP-01) about 3 miles away with its headlight on bright and its ditch lights illuminated. The ME-29 engineer and conductor tried radioing the oncoming train several times but never received a response; however, they were not too concerned because their train had both a *clear* wayside signal and a *clear* cab signal. As a precaution, the ME-29 engineer flashed his train's lights several times. He also began sounding the train's horn for several seconds when he was about ¾ of a mile from a private road crossing. The lights of train NP-01 finally dimmed shortly thereafter.

The Safety Board is convinced that the NP-01 engineer probably fell asleep sometime after his train entered the east end of the siding. He did not respond at all to the train ME-29 crew's repeated radio calls and did not respond timely to the ME-29's flashing headlight beam. He possibly awoke upon hearing the ME-29's horn sounding and dimmed his train lights and extinguished his ditch lights in reaction to meeting an oncoming train, but either was not sufficiently alert or was too startled or disoriented to realize that he needed to apply the brakes.

The Safety Board attempted to determine why the NP-01 engineer might have been sufficiently fatigued to fall asleep. Previous accident investigations[13] have identified three background factors related to fatigue: cumulative sleep loss, the number of continuous hours of wakefulness, and the time of day when the incident occurs. Sleep research[14] has established that, to be fully alert and functioning, people need a certain number of continuous hours of sleep each day, typically 6 to 10 hours, depending on the individual. The engineer's spouse told investigators that the engineer usually slept anywhere from 5 to 9 hours per rest period. She recalled that he retired between 9:30 p.m. and 10:00 p.m. on June 30 and arose the following morning about 8 a.m., meaning that he had slept about 10 hours during his last rest period before the accident and did not have an accumulated sleep debt.

The engineer's continuous hours of wakefulness, together with the time of his work shift probably affected his behavior. His spouse said that he had remained awake from 8 a.m. until he left his residence for an 8:30 p.m. reporting time. Therefore, at the time of the accident, the NP-01 engineer had been awake continuously for about 18 hours. Research shows that the longer an individual goes without sleep beyond the normal waking day of 14 to 16 hours, the greater the occurrence of attention lapses and the longer the duration of the lapses.[15]

The accident occurred at 2:15 a.m. Researchers also have established that two periods of maximum sleepiness occur during a 24-hour period, determined by

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[13] See Safety Study–*Factors that Affect Fatigue in Heavy Truck Accidents* (NTSB/SS-95/01) and Aircraft Accident Report–*Uncontrolled Collision with Terrain American International Airways Flight 808 Douglas DC-8-61, N814CK, U.S. Naval Station, Guantanamo Bay, Cuba, August 18, 1993* (NTSB/AAR-94/04).

[14] Carskadon, M., and Dement, W., "Normal Human Sleep: An Overview," *Principles and Practice of Sleep Medicine*, pp. 16-26, section 1, chapter 2. W.B. Sanders Company, Philadelphia, Pennsylvania, 1994. Roth, T., Roehrs, T., Carskadon, M. and Dement, W., "Daytime Sleepiness and Alertness," *Principles and Practice of Sleep Medicine*, pp. 40-50, section 1, chapter 4. National Commission on Sleep Disorders Research, "Wake Up America; A National Sleep Alert," vol. 1: Executive Summary and Executive Report submitted to the U.S. Congress and the Secretary of Health and Human Services in 1993.

[15] David F. Dinges, Ph. D., "Performance Effects of Fatigue," *Fatigue Symposium Proceedings, November 1-2, 1995,* p. 42, National Transportation Safety Board and NASA AMES Research Center.

physiological fluctuations controlled by the brain.[16] Sleep research suggests that the human body maintains a day-night cycle known as circadian rhythm, which affects, among other biological processes, sleep-wake patterns.[17] Moreover, a circadian nadir normally occurs between 1:00 a.m. and 7:00 a.m. and between 1:00 p.m. and 5:00 p.m., during which workers experience diminished capacity.[18] For many people, including shift workers who work between midnight and 6 a.m., the optimum condition is reduced alertness and the worst case is falling asleep. One study states:

> It has been demonstrated that the quality and quantity of sleep is degraded and performance is impaired as result of working at night. These changes are primarily caused by the disharmony between the night worker's schedule and the underlying circadian rhythms of the body. The two are completely out of phase. The body is programmed to be awake and active by day and asleep and inactive by night, and it is extremely difficult to adjust this program in order to accommodate artificial phase shifts in the sleep-wake cycle.[19]

The NP-01 engineer had been on vacation for 17 days before returning to work on June 30. His spouse told Safety Board investigators that while he was on vacation, he had retired each evening between 9 p.m. and midnight and had awoken each morning between 5 a.m. and 7 a.m. The accident, therefore, occurred on the first day after an extended period during which he had established a sleep-wake pattern.

When individuals change their work-rest schedules, their bodies do not adjust immediately. They normally require from several days to weeks to adapt to work-rest schedule changes. In the interim, as their bodies adjust to the new schedule, they can experience impaired performance, diminished alertness, and increased reaction time. In this case, the engineer did not have the necessary time for his circadian rhythm to match his new sleep-wake cycle. As a result, he probably was not prepared to stay awake all night.

Once NP-01 entered the 13,496-foot-long siding, the engineer had no performance demands for at least 10 minutes before the train reached the west end of the siding. The combined factors of the rhythmic sound and motion produced by the locomotives' engines, the time of day for diminished alertness, the engineer's long period of wakefulness after significantly changing his work-rest schedule, and the lack of sensory stimulation, that is, the darkened cab environment and the absence of conversation with the conductor, would have contributed to the engineer's probably falling asleep.

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[16] Rosekind, M., Gander, P., Connel, L., and Co, E., "Crew Factors in Flight Operations X: Alertness Management in Flight Operations." NASA-FAA Technical Memorandum DOT/FAA/RD-93/18, 1994.

[17] Circadian rhythm is a term used to describe cyclical biological processes that occur at approximately 24-hour intervals in approximate synchrony with the earth's day-night cycle. Sleep-wake patterns, body temperature, hormone levels, and metabolism are some of the processes that have recurring and predictable variations throughout a 24-hour period.

[18] Dinges, D.F., "The Nature of Sleepiness: Causes, Contexts and Consequences." Chapter 9 in Strunkard, A.J., and Baum, A., eds., *Perspectives in Behavioral Medicine*, 1988, p. 162.

[19] Tilley, A.J., et.al., "The Sleep and Performance of Shift Workers," *Human Factors*, 1982, pp. 629-641.

The NP-01 engineer's failure to immediately respond to the repeated visual and aural stimuli from train ME-29 supports the finding that he probably experienced an uncontrolled sleep episode while his train traversed the Kenefick siding. The Safety Board concludes that the NP-01 engineer failed to stop the train at the stop signal because he was probably asleep.

UP's Fatigue Education Program

UP officials indicated that in September 1990, the carrier mailed a fatigue awareness handbook and video to all of its train service and mechanical service employees and their family members. The Safety Board reviewed the fatigue-awareness handbook and video, which address such topics as the body's need for rest, rotating shift work, body rhythms, the beneficial effects of a nutritious diet and exercise, and lifestyle considerations, including family and social life considerations, within the context of shift work. The handouts, which are based on scientific research, describe the physiological aspects of sleep and the effects of fatigue on behavior and performance and explain practicable ways that railroad personnel can address fatigue in their professional and personal lives. The Safety Board concludes that both the handbook and video provided by the UP to employees are valuable information resources for helping railroad personnel and their families understand fatigue issues.

In testimony, the conductors of both trains recalled that they had received the fatigue-related material; the ME-29 engineer and the NP-01 engineer's spouse said that they were unaware that such information or that such a company-sponsored program existed. The personnel and training records of the crewmembers involved in the accident contain no reference or documentation indicating that the material had been sent to them. A UP official indicated that the carrier did not document which employees received this material in 1990. He said that after September 1990, the carrier mailed the handbook and video to each company division and that employees hired after that date would have been encouraged by divisional managers to become familiar with the material.

The fact that some crewmembers and family members had not heard of the UP's fatigue management program indicates that the carrier's action, although laudable, was not completely effective. While it is pleased that the UP attempted to provide relevant information about fatigue to its employees, the Safety Board is concerned that the company did not establish and implement procedures for identifying those individuals who had received the training, did not establish effective procedures for disseminating the information to new employees, and did not establish ongoing procedures for assessing the effectiveness of the program. Such procedures also would have enabled the UP to effectively evaluate future training needs in the area of fatigue. The Safety Board concludes that the UP did not have procedures enabling the company to track the employees who had received the fatigue awareness material.

The Safety Board therefore believes that the UP railroad should issue to all employees, including management personnel, updated fatigue awareness material regarding shift work, work-rest schedules, and proper regimens of health, diet, and rest. In addition, the UP should pursue a systematic approach to this training and establish procedures to ensure that all employees have received this material and understand the dangers of fatigue. Furthermore the company should develop and implement a program affording employees the capability to learn of new developments about this critical railroad safety issue and should establish, at a minimum, an annual management oversight review process for the fatigue awareness program to ensure its effectiveness and to identify ways of improving it.

For a railroad safety program to be successful, it needs the combined support of management and labor. Accordingly, the Safety Board believes that, in conjunction with the UP, the Brotherhood of Locomotive Engineers and the United Transportation Union should discuss the circumstances of this accident with their members and advise them about the operating danger of working while fatigued.

Crew Resource Management

GCOR 1.47 requires that the conductor, among other duties, supervise the operation and administration of the train. GCOR 5.16 stipulates that crewmembers in the engine control compartment be alert for signals and communicate clearly to each other the name or aspect of signals affecting their train movement. The rule also states that if the engineer cannot or does not respond, the crewmembers must immediately take action to ensure safety, using the emergency brake valve to stop the train, if necessary.

After initially providing the Safety Board with several inconsistent statements regarding the events of the evening, the NP-01 conductor stated that he was in the lavatory from the time that the train departed Soldier Creek until immediately before it collided with train ME-29, a period of 20 minutes. Thus, the train passed three signals and was approaching the fourth without the conductor observing the signals and complying with GCOR rules 1.47 and 1.56.

By being absent during much of the trip, the conductor did not properly perform his duties and provide the necessary safety oversight. Had he been present in the locomotive cab and calling out the intermediate signal indications after train NP-01 left Soldier Creek, his interaction with the engineer may have provided the necessary stimulus to keep him awake. At the very least, an alert conductor probably would have detected that the engineer was suffering from fatigue and could either have awakened him or taken actions to stop the train. The Safety Board concludes that the NP-01 train conductor did not provide proper supervision of operating procedures when he left the engineer alone in the locomotive cab for 20 minutes before the collision.

As the GCOR requirements suggest, the safe operation of a freight train requires a team effort between the engineer and the conductor. By working in concert, backing each other up, they provide a redundant safety system. When one individual departs the cab, the safety of train operations is compromised.

Effective operating crew interaction, also known as crew resource management, is particularly important on the UP railroad system, given that most of its freight trains do not have devices providing technological redundancy, such as automatic speed control systems and alerters. The Safety Board understands that the UP is participating in a PTS pilot project (see next section) and is pleased that the carrier is taking this initiative. However, because a PTS control system is not in active operation anywhere on the UP railroad system, the Safety Board thinks that operating procedural changes should be made pending the installation of PTS.

Although the procedure is not actually stipulated in the GCOR or UP operating rules, the train must be stopped when the engineer has to leave the operating cab for any reason. The Safety Board thinks that this practice should apply when the conductor has to leave the locomotive cab for tasks that do not actively support safety redundancy in train operations. The Board is aware that the conductor has operating responsibilities that require leaving the cab, including switching operations, flagging duties at highway-railroad grade crossings, and so forth. However, when performing these tasks, the conductor is still an integral part of the safety redundant system.

An operating train must have an adequate level of either human or technological safety redundancy. The Safety Board therefore believes that the UP should require that freight trains not equipped with cab signals, speed control, and alerters or with a PTS system stop when either one of the two operating crewmembers must leave the locomotive cab, except in instances when the conductor must perform operating tasks actively supporting safety redundancy in train operations.

Positive Train Separation

Neither train in this accident was equipped with a PTS control system, which can prevent trains from colliding by automatically interceding in the operation of a train when an engineer does not comply with the requirements of the signal indication. Had train NP-01 been equipped with PTS, the control system would have prevented this accident by stopping the train when the engineer failed to stop at the red signal. The Safety Board concludes that a fully implemented PTS control system would have prevented the collision at the UP railroad's Kenefick siding, thus saving the life of the NP-01 engineer.

Unfortunately, the Delia collision is merely the latest in a very long list of accidents investigated by the Safety Board in which PTS could have prevented a tragic outcome. The Safety Board initially issued a recommendation addressing this issue in 1970.[20] The Safety Board continued to investigate human-performance-based railroad accidents, which prompted the Board to place PTS on its Most Wanted list in September 1990. Following its investigation of a head-on collision on the Burlington Northern

[20] Railroad Accident Report—*Head-on Collision between Penn Central Trains N-48 and N-49 at Darien, Connecticut, August 20, 1969* (NTSB/RAR-70/03).

Railroad near Ledger, Montana,[21] the Safety Board issued in July 1993 the following safety recommendation to the FRA:

> In conjunction with the AAR and the Railroad Progress Institute, establish a firm timetable that includes at a minimum, dates for final development of required advanced train control system hardware, dates for an implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system. (R-93-12).

In the FRA's July 1994 report to Congress regarding advanced train control, the FRA indicated that it planned to begin a 2-year corridor risk assessment in 1995 to identify and evaluate the conventional rail corridors that would be prime candidates for advanced train control implementation. The study was to contain a geographic information system (GIS) platform to provide the analysis, which would include accidents that may have been prevented by a PTS control system plotted on the GIS. The initial results of the study were presented to the FRA Railroad Safety Advisory Committee (RSAC) in June 1997 for review and further analysis.

At the time of the Delia accident, the FRA and the railroad industry were working on or had planned five joint PTS projects, including the following:

- The UP-Burlington Northern-Santa Fe Pacific Northwest PTS Project. PTS hardware was built and system software was developed for this project in 1995. Deliveries, installations, and testing began in 1996. The project, which has four planned phases, is slated for completion in 1999.
- Amtrak's Incremental Train Control System (ITCS) Project. ITCS wayside equipment was installed in the test bed, and initial system testing began in 1996. The current phase of the project involves producing the hardware and system software for equipping 71 miles of test bed between Kalamazoo, Michigan, and New Buffalo, Illinois (Detroit-Chicago Corridor). Testing this test bed is scheduled to begin in 1998.
- The UP-Amtrak Advanced Train Control System (ATCS) Project. By late 1998, the contract for ATCS hardware and software should be awarded and testing begun on 111 miles of track on the Chicago (Illinois)-St. Louis (Missouri) Corridor.
- Amtrak's Advanced Civil Speed Enforcement System Project. A *Federal Register* notice announced that testing on a system in the Northeast Corridor should begin in 1998.
- Norfolk Southern-CSXT-Conrail Joint PTC Project. In 1997, a vendor was selected to provide design specifications for an on-board platform that is not specific to any PTS protocol. The plan is to develop an economical, interoperable on-board system that features common PTC interfaces.

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[21] Railroad Accident Report—*Head-on Collision between Burlington Northern Freight Trains 602 and 603 near Ledger, Montana, on August 29, 1991* (NTSB/RAR-93/01).

In addition to the test beds mentioned, other railroads (Alaska, New Jersey Transit, New York City Transit, and CSXT) had each budgeted for PTC projects as part of their capital and safety improvement projects. The Safety Board is actively participating in the RSAC on PTS, which is tasked with developing standards and identifying corridors where fully integrated PTS systems can be implemented.

Other Issues

Alerters

Train NP-01's lead locomotive unit, UP 3616, was not equipped with an alerter or alertness device to help the crew maintain vigilance.

According to the eastbound engineer, the speed of train NP-01 near the east end of Kenefick siding was "minimal, as though he [the NP-01 engineer] was trying to get stopped or coasting to a stop…." The ME-29 conductor also said that NP-01 was moving very slowly. CAD records show the train took 9 minutes 24 seconds to cover the distance between the signals. If the NP-01 cab had been equipped with an alerter, depending on the set timing intervals of the device and the time that the engineer probably began to fall asleep, the device may have sensed a lack of movement and awakened him sooner, which may have enabled him to stop the train or at least avoid being fatally injured. The Safety Board concludes that had the striking locomotive been equipped with an alerter, it may have helped the engineer stay awake while his train traveled through the siding.

As a result of its investigation of the August 9, 1990, collision of two Norfolk Southern freight trains near Sugar Valley, Georgia, the Safety Board issued Safety Recommendation R-91-26, urging the FRA, in conjunction with the fatigue study of train crewmembers, to explore the parameters of an optimum alerter system for locomotives.

In an FRA August 12, 1997, response to the recommendation, the Administrator stated that the FRA had initiated research to develop a retrofit for existing alerters to negate the ability of locomotive engineers to reset them while dozing and had approved funding for a prototype and testing. However, the contractor subsequently had withdrawn its proposal, citing the lack of a market for the technology, based on the advent of PTS. The Administrator further stated:

> The FRA has initiated a major project involving rail labor and management to attack the root cause of the fatigue issue.…In addition, we are making major strides toward the implementation of a positive train separation system. These activities address the core issues in the 1990 accident and recommendation 91-26. Our work has superseded the need for the action in recommendation 91-26 and we have decided not to allocate further scarce resources to it. I ask the NTSB reconsider the recommendation and close it based on our alternative action to address its intent."

On November 4, 1997, the Safety Board responded:

> Safety Recommendation R-91-26 urged the FRA, in conjunction with the study of fatigue of train crewmembers, to explore the parameters of an optimum alerter system for locomotives. The Safety Board is disappointed to learn that the FRA plans to take no further action on this recommendation. In the FRA's June 28, response to the recommendation, Acting Administrator S. Mark Lindsey stated that through the Small Business Innovation Personal Solicitation Program, the FRA had awarded two contracts to develop proposals to modify the existing alerter systems so that they cannot be reset by reflex action. Your August 12, 1997, letter does not mention any research under these two contracts. Moreover, your response is predicated on a market analysis submitted by a manufacturer, not on feasibility research requested by this recommendation.
>
> While we applaud the FRA's rail labor and management project, the Safety Board continues to believe that a successful countermeasure to fatigue in the transportation workplace is an optimum alerter system that cannot be reset by reflex action. For the foreseeable future, the implementation of PTS will not be so widespread as to negate the need for such an alerter on locomotives. Since the FRA has declined to act on this recommendation and requested closure, the Safety Board has classified Safety Recommendation R-91-26 "Closed—Unacceptable Action."

The Safety Board still believes that the FRA should revise Federal regulations to require that the rail industry install locomotive alerter systems that require a cognitive response from the engineer to cancel or reset the system. In the interim, the Safety Board believes that the UP should install a cognitive alerter system that cannot be reset by reflex action on all locomotives that operate on lines that do not have a PTS system.

Event Recorder Crashworthiness

To identify measures for improving railroad safety, it is essential that event recorder data be preserved after a catastrophic event. In this accident, fire destroyed the event recorder on train NP-01's lead locomotive unit. Inspection of the fire-damaged units showed that the location of the recording equipment provided satisfactory protection from crash forces. However, the type of encasement designed by the manufacturer did not protect the event recorder from the effects of the fire. The Safety Board therefore was not able to determine what actions the engineer did or did not perform after the train left Kansas City. Consequently, vital information about such functions as braking, throttle manipulation, and the chronological relationship of precollision events, was not available.

The Safety Board has investigated a number of accidents in which event recorder data were compromised by impact forces, water, or fire, including Corona, California, Knox, Indiana, Mobile, Alabama, and, most recently, Devine, Texas.[22] In the investigation report of the Devine collision, the Safety Board again observed that the aviation industry has crashworthiness standards requiring that event recorders on aircraft must be able to withstand impact forces of 3,500 g and fire exposure of 1,100° F for 1 hour. The Board also noted that, despite assuring the Safety Board as recently as August 1997 that it would establish recorder crashworthiness standards for the railroad industry, the FRA had not done so. The Safety Board therefore issued the following safety recommendation to the FRA:

> R-98-30
>
> Working with the railroad industry, develop and implement event recorder crashworthiness standards for all new or rebuilt locomotives by January 1, 2000.

The Safety Board has not yet received a response to Safety Recommendation R-98-30.

Voice Recorders

In a letter dated February 25, 1998, responding to Safety Recommendation R-97-9, the FRA responded that it was reviewing the recommendation and expected to be able to report a substantive response within 60 days. In its preliminary discussion of the recommendation, the FRA stated:

> Unlike event recorders, which have value in determining rules compliance prior to an accident, use of voice recorder information would, as suggested by the recommendation, be limited exclusively to use in an accident investigation. Other uses would be viewed as inappropriate electronic monitoring of employees' conversations in the workplace, whether or not work related.
>
> Capturing voice recordings in a locomotive cab may present practical issues not encountered in aviation. Headsets with intercom capability are the exception, rather than the rule, in locomotive cabs. Significant inter-relationships exist between efforts to limit occupational noise exposure in cabs and the effective recording of conversations. Issues of comfort have also been raised by employees and their representatives when use of headsets has been proposed for reduction of occupational noise exposure. Employee representatives cite 8-12 hour shifts and varying environmental conditions in locomotive cabs.
>
> The potential release of voice recordings subsequent to an accident presents additional issues. A special statutory exception has been required in the aviation context to prevent inappropriate use of voice recordings following events drawing significant notoriety. Enacting fully effective regulations in the absence of special-purpose legislation would appear to present a difficult conflict in public policy.

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[22] For more information, see the following publications: Railroad Accident Report—*Derailment of Freight Train H-BALT1-31 Atchison, Topeka and Santa Fe Railway Company near Cajon Junction, California, on February 1, 1996* (NTSB/RAR-96/05); Railroad Accident Report—*Atchison, Topeka and Santa Fe Railway Company (ATSF) Freight Trains ATSF 818 and ATSF 891 on the ATSF Railway in Corona, California, on November 7, 1990* (NTSB/RAR-91/03); Railroad Accident Report—*Derailment of Amtrak Train No. 2 on the CSXT Big Bayou Canot Bridge near Mobile, Alabama, on September 22, 1993* (NTSB/RAR-94/01); Railroad Accident/Incident Summary Report—*Knox, Indiana, September 17, 1991* (NTSB/RAR-92/02/SUM); and Railroad Accident Report—*Collision and Derailment of Union Pacific Railroad Freight Trains 5981 North and 9186 South in Devine, Texas, on June 22, 1997* (NTSB/RAR-98/02).

> FRA continues to evaluate this recommendation with a view toward offering a more fully considered response. FRA's review would be aided by clarification of the Board's intent. Is it desired that all locomotives, including freight locomotives, be equipped with voice recorders? It is intended that passenger locomotives typically operated by a single employee be included, even if the locomotive cab is inaccessible to other crew members required to be stationed in the occupied passenger coaches (as if often the case in intercity service)?…Since the Board would be the primary user of voice data, does the Board intend to utilize the power conferred under its charter statute to recommend legislation affording appropriate controls on release of voice recordings in the rail mode?

The Safety Board is considering the FRA response.

Conclusions

Findings

1. The train equipment, the track, and the signal system functioned as designed; the dispatcher and train crews were qualified, trained, and tested to properly perform their duties; and no Union Pacific employee tested as a result of this accident was impaired by alcohol or drugs.
2. The hazardous materials cargo did not cause or increase the severity of this accident.
3. The NP-01 engineer failed to stop the train at the stop signal because he was probably asleep.
4. Both the handbook and video provided by the Union Pacific to employees are valuable resources for helping railroad personnel and their families understand fatigue issues.
5. The Union Pacific did not have procedures enabling the company to track the employees who had received the fatigue awareness material.
6. The NP-01 train conductor did not provide proper supervision when he left the engineer alone in the locomotive cab for 20 minutes before the collision.
7. A fully implemented positive train separation control system would have prevented the collision at the Union Pacific railroad's Kenefick siding, thus saving the life of the NP-01 engineer.
8. Had the striking locomotive been equipped with an alerter, it may have helped the engineer stay awake while his train traveled through the siding.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this collision and derailment was the failure of the of the NP-01 engineer to stop at the stop signal, enabled by the failure of Union Pacific management to ensure redundant safety systems for train operations and control, including effective crew resource management techniques and technological advances for crew alertness. Contributing to the collision and derailment was the failure of the Federal Railroad Administration and the railroad industry to aggressively develop and implement a positive train separation control system.

Recommendations

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

To the Federal Railroad Administration:

Revise the Federal regulations to require that all locomotives operating on lines that do not have a positive train separation system be equipped with a cognitive alerter system that cannot be reset by reflex action. (R-99-53)

To the Union Pacific Railroad:

Issue to all employees, including management personnel, updated fatigue awareness material regarding shift work, work-rest schedules, and proper regimens of health, diet, and rest. (R-99-54)

Revise your fatigue awareness program to include a process for documenting which employees receive the currently available fatigue awareness material, any new or updated fatigue-related information, or both, and for determining whether the recipients understand the dangers of working while fatigued. (R-99-55)

Establish, at a minimum, an annual management oversight review process for the fatigue awareness program to ensure its effectiveness and to identify ways of improving it. (R-99-56)

In conjunction with the operating unions, discuss the circumstances of this accident with employees and advise them about the operating danger of working while fatigued. (R-99-57)

Require that freight trains not equipped with cab signals, speed control, and alerters or with a positive train separation system stop when either one of the two operating crewmembers must leave the operating cab, except in instances when the conductor must perform operating tasks actively supporting safety redundancy in train operations. (R-99-58)

Install a cognitive alerter system that cannot be reset by reflex action on all locomotives that operate on lines that do not have a positive train separation system. (R-99-59)

To the Brotherhood of Locomotive Engineers:

> In conjunction with other operating unions and with the Union Pacific Railroad, discuss the circumstances of this accident with your members and advise them about the operating dangers of working while fatigued. (R-99-60)

To the United Transportation Union:

> In conjunction with other operating unions and with the Union Pacific Railroad, discuss the circumstances of this accident with your members and advise them about the operating dangers of working while fatigued. (R-99-61)

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

Adopted: August 31, 1999

John A. Hammerschmidt, Member, filed the following concurring and dissenting opinion on November 18, 1999:

Notation 6899B

Member HAMMERSCHMIDT, concurring and dissenting:

After a careful review of the evidence that was developed during the investigation, I agree with the Probable Cause contained in the Notation Draft that staff originally submitted to the Board:

> The National Transportation Safety Board determines that the probable cause of this accident was the failure of the NP-01 engineer to stop at the stop signal because he was probably asleep and the failure of the NP-01 conductor to provide proper operating safety redundancy by leaving the locomotive cab.

I do not concur with the issuance of Safety Recommendations R-99-58 and R-99-59.

Appendix A

Investigation

The National Transportation Safety Board was notified at 4:01 a.m., eastern daylight time, on July 2, 1997, of a collision and derailment involving two Union Pacific freight trains near Delia, Kansas. The investigator-in-charge and other members of the Safety Board investigative team were dispatched from the Washington, D. C., headquarters office and from the Atlanta, Georgia, and the Chicago, Illinois, field offices. Upon arriving on scene, the Board established investigative groups to study operations, track, signals, mechanical, survival factors, human performance, and hazardous materials.

The Safety Board was assisted in the investigation by the Federal Railroad Administration, the Union Pacific Railroad Company, the Brotherhood of Locomotive Engineers, the United Transportation Union, the Shawnee County Department of Emergency Management, and the Kansas Department of Health and Environment.

Appendix B

Truck Trailers and Contents

Trailer ID	Hazardous Material and Status
YFSZ 36289	108 cartons, 4190 lbs. of pesticide, liquid, toxic, NOS (Abameticin Solution), division 6.1 (poisonous material). **Status:** Recovered. Plastic bottles in a few boxes leaked slightly.
YFSZ 113012	10 cylinders, 55 lbs. each of several refrigerant gases, division 2.2 (nonflammable gas). **Status:** Cylinders recovered intact
NONZ 173810	13 packages, 78 lbs. of paint in aerosol cans with a flammable gas propellant, shipped as paint, division 2.1 (flammable gas). **Status:** Not recovered.*
NONZ 191287	4 packages, 152 lbs. of wood bleach shipped as hydrogen peroxide aqueous solution, division 5.1 (oxidizer) and sodium hydroxide solution, class 8 (corrosive material). **Status:** Not recovered.
KCSZ 211906	310 packages, 1,864 lbs. of paint in aerosol cans with a flammable gas propellant, shipped as paint, division 2.1 (flammable gas). **Status:** Not recovered.
NONZ 192194	32 packages, 205 lbs. of paint in aerosol cans with a flammable gas propellant, shipped as paint, division 2.1 (flammable gas). **Status:** Not recovered.
YFSZ 42688	3 pails, 133 lbs. of corrosive liquid, NOS (ammonium hydroxide), class 8 (corrosive material). **Status:** Not recovered. 1 pail, 43 lbs. of corrosive liquid, NOS (tripropylene glycol diamine), class 8 (corrosive material). **Status:** Not recovered.
RDWZ 221251	25 packages, 1,055 lbs. of coating solution, class 3 (flammable liquid). **Status:** Not recovered. 18 packages of molybdenum 99/technetium 99m generators with between 0.028 and 80 millicuries of radioactive materials, NOS (molybdenum 99/technetium 99m), UN 2982; 10 packages White I and 8 packages Yellow II. **Status:** Some remains (melted lead, springs and bits of cardboard) of severely fire damaged packages were found.
* Each shipment listed as not recovered was in truck trailers damaged or destroyed by fire.	

Appendix C

Signal Changes

The sequence of signal and switch events at the east and west ends of Kenefick siding is listed below. (The best wayside signal aspect would have been a red over yellow. The best cab signal aspect would have been a solid yellow).

Time	Control Point	Switch Event
1:27:57	West Kenefick	Switch normal position (Main track movement).
1:46:16	CP East Kenefick	Request reverse switch (Main track movement to-from the siding track).
1:46:18	West Kenefick	Request eastbound signal (train ME-29).
1:46:34	East Kenefick	Switch reverse. (The switch was lined for train NP-01 to move into the siding track .)
1:46:36	West Kenefick	Eastbound signal cleared for train ME-29.
1:46:47	East Kenefick	Westbound signal cleared for train NP-01.
2:05:59	East Kenefick	Westbound signal at “stop”, switch reverse, OS track occupied for train NP-01. (The train entered the siding).
2:06:01	East Kenefick	Siding track occupied by train NP-01.
2:09:48	East Kenefick	East approach unoccupied
2:10:16	East Kenefick	Switch reverse, OS track unoccupied. (Train NP-01 was completely in the siding.)
2:10:19	East Kenefick	Request normal switch for main track movement.
2:10:49	East Kenefick	Switch normal (for main track movement).
2:10:49	East Kenefick	Request eastbound signal for train ME-29.
2:11:02	East Kenefick	Eastbound signal cleared.
2:12:02	West Kenefick	West approach occupied by train ME-29.
2:15:03	West Kenefick	Siding track occupied by train NP-01. (The train was approaching the west end of the track.)
2:15:08	West Kenefick	Eastbound signal at stop, switch normal, OS track occupied by train ME-29. (The head end of train ME-29 passed the eastbound signal at the west end of Kenefick Siding.)
2:15:23	West Kenefick	Westbound signal, main track, showed cleared.

Appendix D

Union Pacific's 1998 Fatigue Program

ALERTNESS MANAGEMENT PROGRAM ROLL-OUT PLAN

This program represents an integrated and comprehensive effort to address the issues of fatigue and rest at the Union Pacific Railroad Company. The following components constitute the major activities for 1998:

1. Strategic, Operational, and Project Plans Development

   This planning process is critical to assure the approach to managing employee fatigue and improving alertness is comprehensive and that the objectives of the program are met. Strategic, Operational and key project plans will be completed by June, 1998.

2. Crew Scheduling

   The Crew Scheduling Project is a vehicle to implement fatigue management within the transportation craft. Listed below is a status report of the project.

   - Alertness Solutions is in the process of analyzing data in order to develop appropriate scheduling approaches for the corridor selected for the first pilot.
   - Initial contract negotiation discussions with the UTU and BLE [Brotherhood of Locomotive Engineers] begin 4/28/98.
   - Fatigue and alertness education efforts have begun with initial training for the involved union representatives, operating managers, and labor relations managers.
   - In June, 1998, educational efforts will continue with general education in a "townhall" meeting format for employees.

3. Education/Training and Communications

   Education and training will be the foundation to all other projects in the overall program.

   - General fatigue education is currently being provided to operating employees in training sessions that coincide with bi-annual rules examinations.
   - General Awareness educational materials such as a video, brochures, and books should be available for use by mid summer, 1998.

4. Napping/Policy Implementation Project

   The Napping/Policy Implementation Project will offer employees the opportunity to use a planned structured nap when operationally appropriate.

- First pilot is currently underway on the St. Louis Service Unit. Evaluation of this pilot is scheduled for May and June of 1998.
- 4 additional pilots are scheduled for mid-summer 1998.
- Napping will also be included in any crew scheduling efforts.

5. Lodging Task Force

   A Lodging Guidelines and Evaluation document has been developed which will be reviewed by this task force and plans for implementation will be developed. This team is currently being formed and an implementation plan should be completed by July, 1998.

The following components of the program are currently in the developmental stages:

6. Minimum Rest and A.M. Mark-Up
7. Technology Implementation Project

   A team will be formed to search out and analyze the use of products which could have an impact on fatigue and determine the feasible use of the products within the railroad environment.

8. Healthy Sleep Project

   The Healthy Sleep Project will involve the identification and treatment of sleep complaints and disturbances among the Union Pacific workforce.

9. General Fatigue Countermeasures Project

   The General Fatigue Countermeasures Project is a series of sub projects which will be developed within specific work groups that will address fatigue related issues and develop countermeasures.

10. Measurement Task Force

    The Measurement Task Force will be responsible for determining appropriate measurements which will look at whether cultural changes are occurring, and the impact of fatigue on productivity.

11. Emergency Response Project

    The Emergency Response Project will develop principles and guidelines to assist Union Pacific in developing policies and procedures for Emergency Response Teams.

Abbreviations and Acronyms

AAR	Association of American Railroads
ACS	Automatic Cab Signal
AMR	American Medical Response
ATCS	Advanced Train Control System (another term for PTS)
ATS	Automatic Train Stop
CAD	computer-aided dispatching
CFR	*Code of Federal Regulations*
COFC	Container On Flat Car
cp	control point
FRA	Federal Railroad Administration
GCOR	*General Code of Operating Rules*
GIS	geographic information system
HRA	health risk appraisal
ITCS	Incremental Train Control System (another term for PTS)
MARC	Maryland Rail Commuter
Mo99	molybdenum 99
MP	milepost
NASA	National Aeronautics and Space Administration
PTS	positive train separation
RSAC	Railroad Safety Advisory Committee
SCSD	Shawnee County Sheriff's Department
SLT	Senior level team
TCS	traffic control system
TOFC	trailer on flatcar
UP	Union Pacific