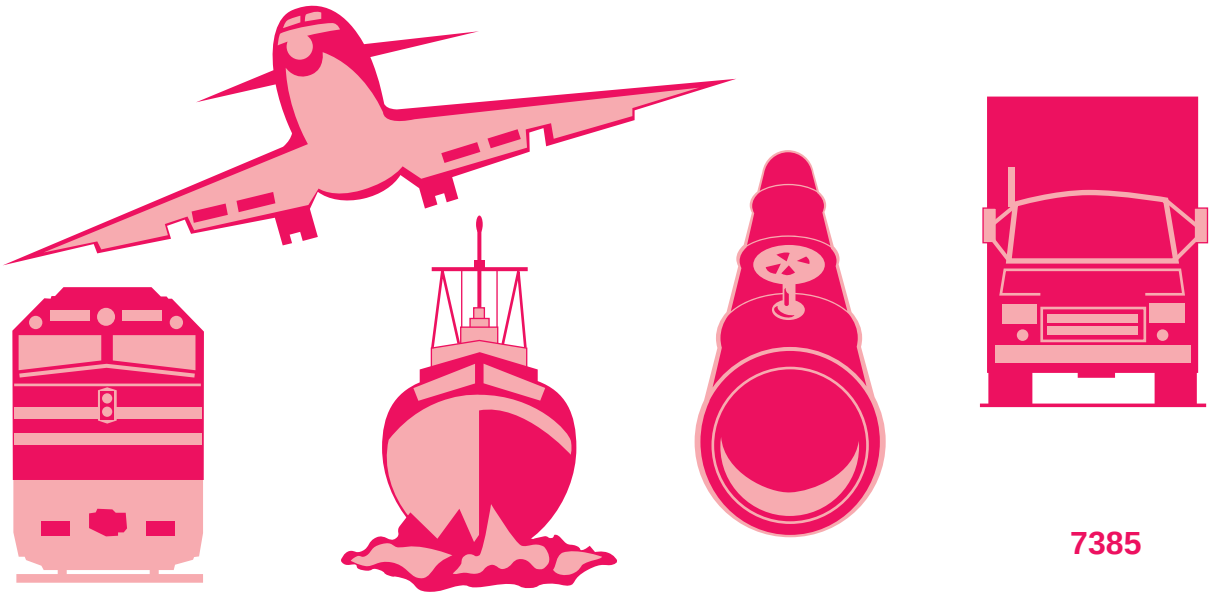
PB2001-916303
NTSB/RAR-01/03

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

COLLISION OF AMTRAK TRAIN 304-26 WITH A HIGHWAY VEHICLE AT A HIGHWAY-RAIL GRADE CROSSING MCLEAN, ILLINOIS SEPTEMBER 26, 1999



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Railroad Accident Report

Collision Of Amtrak Train 304-26 With A Highway Vehicle At A Highway-Rail Grade Crossing McLean, Illinois September 26, 1999

NTSB/RAR-01/03
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Notation 7385
Adopted September 18, 2001

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

National Transportation Safety Board. 2001. *Collision of Amtrak Train 304-26 with a Highway Vehicle at a Highway-Rail Grade Crossing, McLean, Illinois, September 26, 1999.* Railroad Accident Report NTSB/RAR-01/03. Washington, DC.

Abstract: On September 26, 1999, about 5:08 p.m. (central daylight time), northbound National Railroad Passenger Corporation (Amtrak) train 304-26, which was en route from St. Louis, Missouri, to Chicago, Illinois, collided with an automobile, which was westbound on U.S. Route 136. The collision occurred where the Union Pacific Railroad's St. Louis Division main line and U.S. Route 136 cross near McLean, Illinois. The automobile driver and passenger were killed as a result of the collision. Amtrak train 304-26 did not derail, and no injuries to the train crewmembers or passengers were reported. Neither the flashing lights nor the gates for the grade crossing activated to warn the automobile driver of the approaching train.

The safety issues discussed in this report are Union Pacific Railroad's signal maintenance procedures, Union Pacific Railroad's postaccident site securement procedures for highway-rail grade crossing accidents, and postaccident toxicological testing.

As a result of its investigation, the Safety Board issued safety recommendations to the Federal Railroad Administration, the Union Pacific Railroad, and the Brotherhood of Railroad Signalmen.

Contents

Executive Summary

On September 26, 1999, about 5:08 p.m. (central daylight time), northbound National Railroad Passenger Corporation (Amtrak) train 304-26, which was en route from St. Louis, Missouri, to Chicago, Illinois, collided with an automobile, which was westbound on U.S. Route 136. The collision occurred where the Union Pacific Railroad's St. Louis Division main line and U.S. Route 136 cross near McLean, Illinois. The automobile driver and passenger were killed as a result of the collision. Amtrak train 304-26 did not derail, and no injuries to the train crewmembers or passengers were reported. Neither the flashing lights nor the gates for the grade crossing activated to warn the automobile driver of the approaching train. A Union Pacific Railroad signal maintainer had worked on the grade crossing warning devices earlier that day; he had finished his work and left the McLean grade crossing area about 4:30 p.m.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the signal maintainer to remove a jumper wire from the grade crossing control relay and, as required by the Union Pacific Railroad's written procedures, to verify the operational status of the grade crossing equipment after he had completed the maintenance work.

The Safety Board's investigation examined the following safety issues:

- Union Pacific Railroad's signal maintenance procedures,
- Union Pacific Railroad's postaccident site securement procedures for highway-rail grade crossing accidents, and
- Postaccident toxicological testing.

As a result of its investigation, the Safety Board makes safety recommendations to the Federal Railroad Administration, the Union Pacific Railroad, and the Brotherhood of Railroad Signalmen.

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Factual Information

Accident Synopsis

On September 26, 1999, about 5:08 p.m.,[1] northbound National Railroad Passenger Corporation (Amtrak) train 304-26, which was en route from St. Louis, Missouri, to Chicago, Illinois, collided with an automobile, which was westbound on U.S. Route 136. (See figure 1.) The collision occurred at the highway-rail grade crossing (DOT #290 964A) where the Union Pacific Railroad's (UP's) St. Louis Division main line and U.S. Route 136 cross near McLean, Illinois. The automobile driver and passenger were killed as a result of the collision. Amtrak train 304-26 did not derail, and no injuries to the train crewmembers or passengers were reported.

Figure 1. Postaccident scene showing rear of the destroyed vehicle.

[1] Times given in this report are central daylight time.

Accident Narrative

Preaccident Events

Union Pacific Railroad. On September 26, 1999, at 12:30 p.m., the UP Signal Operations Center in Omaha, Nebraska, called the signal maintainer assigned to the Bloomington, Illinois, territory (which includes the town of McLean) for duty. The Harriman Dispatch Center reported that the dispatcher was having problems with the south remote-controlled, power-operated switch on the McLean siding. Soon after being called, the signal maintainer departed for McLean. During postaccident interviews conducted by the Federal Railroad Administration (FRA), the maintainer stated that after arriving in McLean, he drove through the town and noticed that the grade crossing warning devices for the nearby Railroad Avenue crossing were operating (gates down, lights flashing) although no trains were in the area. He stated that he stopped at the Railroad Avenue crossing and saw that the grade crossing predictor, a Safetran GCP 3000 unit, had activated the warning devices due to a high and fluctuating EZ[2] value. The maintainer stated that he calibrated the unit, correcting the problem. He then continued to the south power-operated switch of the McLean siding that the signal operations center had called him to check.

After completing his work on the power switch equipment, the maintainer stated that he decided to inspect the grade crossing predictor unit for the nearby U.S. Route 136 grade crossing. The U.S. Route 136 grade crossing is just north of the power-operated switch machine that the maintainer had been sent to check. The maintainer stated that the EZ value for the siding track was fluctuating but not enough to cause the warning devices to activate with no trains present. The maintainer stated that he then walked the siding track to inspect all track connections. The maintainer found and replaced a frayed bond wire. The maintainer then returned to the grade crossing predictor unit for the U.S. Route 136 crossing and recalibrated the unit.

While the maintainer was in McLean, a festival was taking place in the town. The maintainer stated that to avoid stopping highway traffic for the festival while he went through the calibration process on the U.S. Route 136 grade crossing predictor unit, he decided to use a jumper wire to falsely energize the crossing control relay[3] (also known as the XR relay) for the U.S. Route 136 grade crossing while he worked. (See figure 2.) A crossing control relay is normally in an energized state; then, when the train detection system detects a train, it automatically de-energizes the crossing control relay, which activates the crossing's flashing lights and gates. By artificially energizing the relay, the maintainer was temporarily circumventing the system's ability to activate the crossing's flashing lights and gates.

The maintainer said he routinely used jumper wires in this manner to keep the warning devices from activating during maintenance work. UP rules required the maintainer to obtain authority from the dispatcher to protect any train movements in the

[2] This is the operating voltage that monitors train traffic approaching the crossing.

[3] The *crossing control relay* is the control circuit relay that initiates the crossing warning devices.

Figure 2. Crossing control relay.

area before he falsely energized the crossing control relay. The maintainer did not obtain such authority from the dispatcher. (See discussion in "UP Operating Rules" section.)

The maintainer stated that after recalibrating the grade crossing predictor unit, he thought he removed the jumper wire on the crossing control relay and then notified the UP signal operations center that the south power switch was back in service and operational. The maintainer did not inform the UP signal operations center that he had worked on any crossing equipment in addition to the south power switch. The maintainer stated that he departed McLean about 4:30 p.m. en route to his residence.

Amtrak. The Amtrak train 304-26 crewmembers, including an engineer, a conductor, and an assistant conductor, reported for duty in St. Louis, Missouri, on September 26, 1999, at 1:15 p.m. They departed St. Louis about 2:00 p.m., after the locomotive unit had been given a daily inspection and the required initial terminal air brake test had been performed on the consist.

The Amtrak train, which was about 400 feet long and consisted of one locomotive unit (a GE B32-8WH locomotive), three passenger coaches, and one café car, was destined for Chicago, Illinois. The locomotive was being operated with the short hood forward, with the train engineer seated at the controls on the right side of the locomotive. The conductor and assistant conductor were in the coach cars with the passengers.

Locomotive event recorder data indicated that Amtrak train 304-26 was traveling about 74 mph as it approached the U.S. Route 136 highway-rail grade crossing a few minutes after 5:00 p.m. The train was operating on a clear signal. The engineer stated that he was sounding the train's horn when he observed an automobile approaching the crossing from the east; the vehicle did not appear to be reacting to the horn. The engineer could not recall seeing the highway-rail grade crossing warning devices operating, but he did recall that the car did not appear to weave around as he typically sees when vehicles drive around lowered gates.

Highway Vehicle. On September 26, 1999, about 4:00 p.m., a 1995, 2-door, Chevrolet Monte Carlo passenger vehicle, occupied by the registered automobile owner's son and a passenger, departed westward from Champaign-Urbana, Illinois. According to Illinois State Police reports, the automobile had had brake work done in April 1999 and an oil change sometime in July or August 1999. The automobile was westbound on U.S. Route 136 as it approached the highway-rail grade crossing near the town of McLean shortly after 5:00 p.m. The speed limit on U.S. Route 136 in the vicinity of the highway-rail grade crossing is 35 mph.

See figure 3 for a diagram representing the accident location.

The Accident

When the Amtrak engineer realized a collision with the automobile at the U.S. Route 136 grade crossing was imminent, he placed the train's air brakes into emergency. The engineer stated that he then braced himself inside the locomotive cab. About 5:08 p.m., the Amtrak train, traveling at a recorded speed of 74 mph, struck the automobile, which was traveling at an estimated speed of 27 mph. The train came to a stop 3,216 feet from the crossing. No railroad equipment derailed as a result of the collision.

The automobile separated into two parts as a result of the impact. The front portion of the automobile became lodged on the front of the locomotive, while the rear portion came to rest about 203 feet north of the crossing and 7 feet east of the railroad tracks. Both automobile occupants were ejected from the vehicle. According to State police reports, windshield obstructions and radio volume settings could not be determined due to the induced damages to the automobile. No brake light lamp filaments from the automobile were available for testing due to collision damage.

Emergency Response

When the train came to a stop, the Amtrak conductor, who was in the lead coach car with the assistant conductor, walked through the train, advising and instructing the passengers. He then detrained through the rear coach car and observed the wreckage. He placed an emergency 911 call using a cellular telephone. According to both the engineer

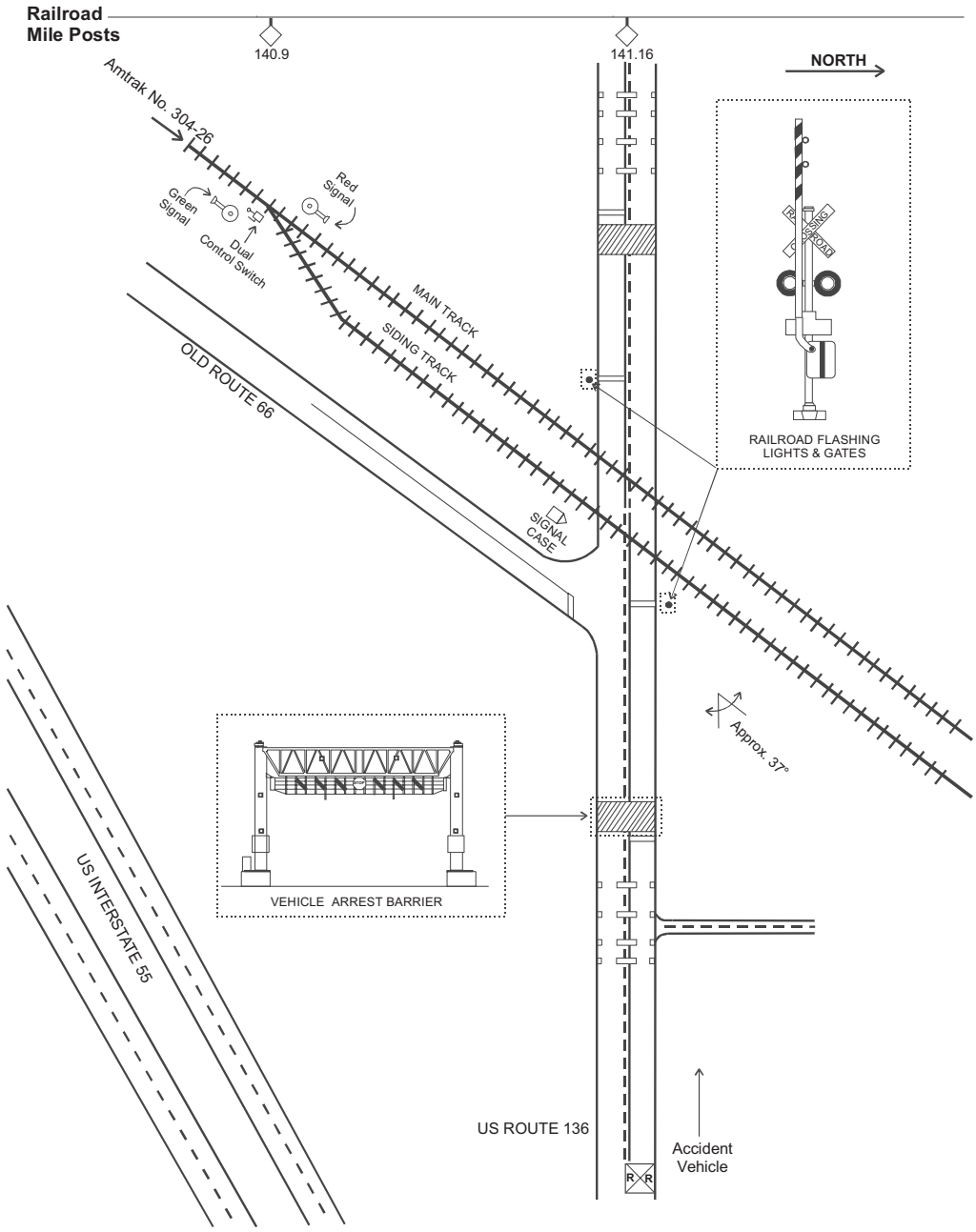

Figure 3. Layout of the accident area.

and the conductor, emergency medical services personnel responded within minutes of the call. Additionally, a physician who was onboard the train at the time offered his services at the scene. There were no reported injuries to the train crewmembers or passengers.

The Illinois State Police requested on-scene emergency medical services personnel to evaluate the engineer about 7:30 p.m. that evening. The State police then conducted a brief interview with the engineer. The engineer did not report any physical injuries, but he

requested that Amtrak officials relieve him of his duties. An Amtrak road foreman of engines advised the State police that he would take control of train 304-26 and move it into Chicago's Union Station as soon as it was released from the accident scene. The conductor remained on duty with train 304-26. About 9:04 p.m., the Amtrak train was cleared to continue by the deputy coroner.[4]

Postaccident Action

Amtrak

Following the collision, the Amtrak engineer used the radio keypad to initiate an emergency call-in, notifying the UP train dispatcher of the accident. During the radio conversation, the dispatcher asked the engineer how the warning devices at the crossing had operated. The Amtrak engineer responded that he did not notice whether the devices were operating, because his attention had been focused on the oncoming automobile. The UP dispatcher advised the Amtrak engineer that a UP signal maintainer would be dispatched to the scene to inspect the equipment.

Union Pacific Railroad

The UP signal operations center notified the UP manager of signal maintenance of the accident about 5:36 p.m. and informed him that the signal maintainer for the territory had been dispatched to the scene. The manager of signal maintenance directed the UP signal operations center to contact the signal technician for the area and dispatch him to the accident scene.[5]

According to FRA and Safety Board interview statements, about 6:15 p.m., the signal maintainer and the signal technician said they both arrived at the scene in their company vehicles from different directions. They parked their vehicles and walked toward the railroad tracks. The technician headed toward the crossing to assess damages, while the maintainer continued toward the signal case, which houses the crossing control equipment, and entered it. After assessing the damages at the crossing, the technician walked back and entered the signal case.

The deputy coroner stated that when he arrived at the scene, he walked to the signal case after noticing that the door was open. Inside, he said he saw the signal maintainer, alone, holding some type of jumper wire while working on the equipment. The deputy coroner could not recall the color of the jumper wire. The deputy coroner asked a State police officer to secure the signal case. The State police officer reported going to the signal case about 6:25 p.m. and asking the two railroad employees inside it to exit the case

[4] The State police also assigned the deputy coroner the duty of reconstructing the accident scene.

[5] The signal maintainer was responsible for testing and maintaining all wayside and crossing equipment for his assigned territory, while the signal technician took care of the electronic components of wayside and crossing equipment for several maintainers' territories. The manager of signal maintenance supervised both employees.

and wait until the accident reconstructionist (the deputy coroner) gave them authorization to begin testing.

The signal technician told investigators that the signal maintainer told him that he did not recall removing any jumper wires from the equipment when he entered the signal case, nor did he recall seeing any jumper wires. The technician stated that he instructed the maintainer to return to Bloomington, Illinois, to retrieve a laptop computer that would be required to download the data from the crossing event recorder module.

During this period, a McLean police officer identified and interviewed five witnesses,[6] who stated that the crossing warning devices did not activate for Amtrak train 304-26. The signal technician stated that he then contacted the manager of signal maintenance to notify him of the situation and to request his presence on the scene.

The manager of signal maintenance stated that he arrived about an hour after talking to the technician. With the manager of signal maintenance, the signal technician, and the State police present, a download was performed to acquire the data from the crossing event recorder module (time of download recorded as 7:18 p.m.). The event recorder data indicated that the crossing control relay did not de-energize for Amtrak train 304-26. The data also indicated that track No. 2 (siding track) had been calibrated earlier in the day and that Amtrak train 304-26 was the first train to travel through the crossing since the calibration.

The manager of signal maintenance stated that he asked the signal maintainer about previous work done at the U.S. Route 136 crossing. The maintainer told the manager of signal maintenance that earlier in the day he had been at the crossing and had replaced a bond wire on track No. 2. He said he then used a red jumper wire with alligator clips to keep the crossing control relay energized as he recalibrated the grade crossing predictor unit at the U.S. Route 136 crossing. He further stated that he had finished his work at the crossing by removing the jumper wire.

The manager of signal maintenance stated that he found a 4-foot piece of blue wire on the floor of the signal case when he first entered. The wire had eyelets on both ends, but one of the eyelets was broken and missing a piece. He stated that he then checked the crossing control relay but did not find the missing piece of the eyelet on any of the relay terminals. The manager of signal maintenance further stated that he removed the original event recorder module to protect the recorded accident data and placed a spare event recorder module in the grade crossing predictor unit. FRA inspectors arrived on scene later that evening and began testing the crossing equipment.

On September 27, the crossing was completely retested with FRA inspectors present. Re-enactments were conducted simulating train movements through the crossing both with and without a jumper wire in place to keep the crossing control relay energized.

[6] The witnesses were bystanders who had been near the crossing and the driver of a vehicle that had just crossed the crossing.

Following the re-enactments, a download of the event recorder module was acquired to compare this information to the downloaded data from the accident.

The manager of signal maintenance told the FRA that when he and the UP attorneys met with the signal maintainer on that day, the maintainer told them, "I must have left the jumpers on and killed two people." Also on September 27, the UP notified the signal maintainer that he was being removed from service for failing to follow UP procedures. Specifically, he was cited for failing to protect against train movements, violating roadway worker requirements (bonding[7] without track and time), and failing to perform required tests at the highway-rail grade crossing.

Federal Railroad Administration

Upon arrival at the crossing on the evening of the accident, the FRA took the lead and headed the investigation.[8] FRA inspectors conducted the postaccident testing of the crossing warning equipment and interviewed the Amtrak train crew, UP signal personnel, and vehicle arresting barrier[9] personnel.

Federal regulations impose requirements on railroads to report all grade crossing accidents. Notification must be provided to the National Response Center within 24 hours of the occurrence. On September 26, at 6:57 p.m., the UP notified the National Response Center by telephone of the accident.[10] In this notification, the UP reported the flashing lights and gates at the U.S. Route 136 crossing as operating when the accident occurred. On September 27, at 1:42 p.m., the UP again notified the National Response Center of the accident; in the second notification, the UP reported that the crossing warning devices had not functioned at the time of the accident.[11]

In addition to immediate telephone notification, regulations require railroads to submit to the FRA a report of all railroad accidents/incidents pursuant to 49 *Code of Federal Regulations* (CFR) 225.11 (rail equipment accident/incident report)[12] and 234.9 (highway-rail grade crossing accident/incident report).[13] The UP and Amtrak both submitted the required FRA F 6180.54 reports. The FRA F 6180.54 report submitted by the UP indicated driver inattentiveness as the primary cause of the accident. Amtrak also submitted the required FRA F 6180.57 report, which indicated that the automobile had been driven around or through the gate at the crossing. All the submitted forms were

[7] *Bonding* is the installation of metallic connections attached to adjacent rails to ensure electrical conductivity.

[8] Based on the initial National Response Center report #500202 on this accident, the Safety Board gathered information about, but did not launch investigators to, this accident.

[9] Information on the vehicle arresting barrier is provided later in the report.

[10] National Response Center Railroad Report #500202.

[11] National Response Center Railroad Report #500306.

[12] Form FRA F 6180.54.

[13] Form FRA F 6180.57.

added to the FRA accident database. Such forms are accessible through the FRA website.[14]

The FRA's report on its McLean accident investigation found that the primary probable cause of the accident was that the crossing control relay remained falsely energized during the approach and passage of Amtrak train 304-26, which resulted in a collision with the automobile at the crossing. Following its investigation, the FRA issued violations to the UP for (1) interference with normal functioning of a highway-rail grade crossing signal system in accordance with 49 CFR 234.209 and (2) failing to submit a revised report after the cause of the accident was known to the UP, in accordance with 49 CFR 225.11 (reporting of accidents/incidents). The FRA also issued a violation to Amtrak for failing to submit a revised report after the cause of the accident was known to Amtrak, in accordance with 49 CFR 225.11. For several months after the FRA issued violations to the UP and Amtrak for failing to submit a revised report after the cause of the accident was known, the UP and Amtrak initial accident reports remained available through the FRA website.

On March 10, 2000, the UP signal maintainer received a notice from the FRA for failing to comply with Federal regulations while working at McLean, Illinois, on September 26, 1999. The FRA noted that the signal maintainer failed to comply with 49 CFR 214.313(c), "Each roadway worker is responsible to ascertain that on-track safety is being provided before fouling a track," 49 CFR 234.209, "The normal functioning of any system shall not be interfered with in testing or otherwise without first taking measures to provide for safety of highway traffic that depends on normal functioning of such system," and 49 CFR 234.257(a), "Each highway-rail crossing warning system shall be tested to determine that it functions as intended when it is placed in service. Thereafter, it shall be tested at least once each month and whenever modified or disarranged." The FRA determined that the signal maintainer was unfit for the performance of safety-sensitive functions[15] and disqualified the signal maintainer from working in a safety-critical position on any railroad without direct supervision by a railroad manager or supervisor.

Damage

The 1995 Monte Carlo passenger car was destroyed (estimated worth $8,500) in the collision. Amtrak estimated total damages to the locomotive unit at $7,823. The UP did not report any damage to the signal equipment or track structure.

[14] Information obtained from FRA website at <http://www.fra.dot.gov>.

[15] As provided under 49 CFR 209.301 and 49 CFR 209.303(a), a signal maintainer is a safety-sensitive employee.

Railroad Personnel Information

Amtrak Train Crewmembers

The Amtrak engineer had undergone and passed the required training program to be a certified locomotive engineer in accordance with Federal regulations. The Amtrak crewmembers had attended operating and safety rules classes in the past year. In accordance with the Hours of Service Act, the train crewmembers had been off duty for at least 8 hours before reporting to work on September 26.

UP Signal Maintainer

The 55-year-old signal maintainer was originally hired by a predecessor railroad of the UP in January 1968. For the past 32 years, he had been a railroad employee working in the signal department. He had been responsible for the Bloomington territory, which included the town of McLean, for about 10 years. The maintainer's employee records indicated he was qualified under the roadway worker protection requirements as an employee-in-charge, flagman, lookout, lone worker, and machine operator. His records further indicated qualifications in "signal test & maintenance procedures," and "on-track safety - all categories."

UP disciplinary records show that in March 1996, after conducting a maintenance inspection on the Bloomington territory, the UP issued a letter of reprimand to the signal maintainer for not complying with the maintenance requirements on his territory. The letter of reprimand specifically cited the failure to comply with Southern Pacific Railroad Rule 71.2 (Duties of Employees); Rule 71.5.4.61 (FRA Shunt Fouling Circuit Test Requirements CFR 236.104); Rule 71.2.8.1 (Signalmen and Signal Maintainers); Rule 71.5.4.14 (General Instructions for Signal Employees); Rule 71.5.4.16 (General Requirements - All Systems); and Rule 71.4.23 (Pole and Power Supply). No other entries concerning disciplinary actions were found in the signal maintainer's record.

Company records indicate the UP signal maintainer had been off duty for about 44.5 hours (since 4:00 p.m., September 24) before responding to the 12:30 p.m. trouble call on September 26, 1999.

When the Safety Board began its investigation of this accident, several months after the accident occurred, the signal maintainer was unwilling to provide information to the Safety Board. The Safety Board was unable to obtain a 72-hour history for the maintainer, and the maintainer would not give Safety Board investigators his account of the events preceding the accident.

Automobile Occupant Information

Both automobile occupants had normal vision and hearing. State records indicate the driver had been issued a driver's license on May 6, 1999. There was no record of previous traffic citations or warnings for this license.

Meteorological Information

Weather conditions at the time of the accident were reported as no precipitation, visibility at 15 miles with scattered cloud cover at 8,000 feet, a temperature of 84° F, and winds out of the south/southwest at 15 knots, gusting to 22 knots. Sunset was at 6:48 p.m.

Track and Site Information

Accident Site

McLean Village (McLean), a rural town with a population of about 800, is centrally located in the State of Illinois, about 50 miles northeast of Springfield, Illinois. McLean is situated near the intersection of U.S. Interstate Highway 55 and U.S. Route 136. The UP St. Louis Division, Springfield Subdivision, main line track passes through McLean in a southwest to northeast direction, dividing the town about in half. U.S. Interstate Highway 55 roughly parallels the UP main line; U.S. Route 136 runs in an approximately east/west direction. Two highway-rail grade crossings are within the McLean town limits, the grade crossings at U.S. Route 136 and at Railroad Avenue. Both grade crossings are equipped with active warning devices.

In the vicinity of McLean, U.S. Route 136 is a two-lane asphalt road intersecting the UP tracks at the south end of the town. The crossing surface is made of rubber slabs. At the time of the accident, the roadway surface leading up to and at the crossing where the accident occurred appeared to be in good or new condition, and the roadway width at the crossing measured about 32 feet. About 93 feet to the east of the tracks, U.S. Route 66 intersects U.S. Route 136 in a "T" intersection, with U.S. Route 66 leading southward.[16] About 300 feet to the east of the tracks, another roadway, leading northward, intersects U.S. Route 136. In the vicinity of the crossing, the shoulders are about 2.5 feet wide and in good condition. The posted regulatory speed limit on U.S. Route 136 in this vicinity is 35 mph.

Grade Crossing Signage and Devices

General. Highway-rail warning devices are designed to notify motorists of the presence of a railroad crossing in their path of travel. Typically, as a vehicle approaches a

[16] Distance was measured from the nearest rail at the crossing to the western edge of the stopline on U.S. Route 66.

crossing, the driver encounters an advance warning sign.[17] The advance warning sign is placed in a location that provides the driver time to react to the upcoming crossing and take appropriate action. After an advance warning sign is recognized, the automobile driver begins to identify and locate the crossing and the associated control devices to form a "go/no-go" decision.

At a passive crossing,[18] crossbucks[19] are typically located at the highway-rail intersection to identify the crossing to the driver. The crossbuck notifies the driver to operate the vehicle in a manner that will allow the driver to take appropriate action until a determination can be made to safely continue through the crossing.

At an active crossing,[20] such as the U.S. Route 136 grade crossing, the warning devices automatically activate through some form of train detection and inform the driver of the approach or presence of trains. A driver can then take appropriate actions based on information provided by the warning devices.

U.S. Route 136 Grade Crossing Signage. Nearest the crossing, a stop line extending across the approach lane is about 36 feet from the nearest rail. Near the vehicle arresting barrier apparatus, a 20-foot zone of diagonal stripes, beginning at about 171 feet from the nearest rail, indicates an area in which vehicles should not stop. Immediately to the east of the striped zone is a second stop line extending across the approach lane. About 225 feet to the east of the nearest rail is a set of three short lateral stripes, one across the center line and one at each road edge. This three-stripe set is repeated at 275, 325, and 375 feet from the nearest rail. The grade crossing pavement marking, consisting of a large "X" and the letters "RR," extends from about 512.6 to 564.6 feet east of the nearest rail. The solid yellow stripe demarking a no-passing zone extends from the crossing itself out to a point about 543.6 feet east of the crossing. (Refer to figure 3 for layout of crossing.)

U.S. Route 136 Grade Crossing Warning System. The grade crossing inventory number for the U.S. Route 136 crossing is DOT #290 964A. The UP grade crossing warning system is equipped with flashing lights, bells, and gate arms. Ten round, 12-inch-diameter flashing light units mounted on two signal masts provide warning for all directions of highway traffic.

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[17] An *advance warning sign* (designation W10-1 in the *Manual on Uniform Traffic Control Devices*) is a round, black and yellow sign located before the crossing to alert drivers of an upcoming crossing. The minimum diameter of the sign is 36 inches.

[18] A *passive crossing* is a type of highway-rail crossing that has nonactive traffic control devices, including signs, pavement markings, and other devices, located at or in advance of the grade crossing to indicate to the motorist the presence of the crossing. The devices do not change aspect upon the approach or presence of a train.

[19] A *highway-rail grade crossing crossbuck* (designation R15-1 in the *Manual on Uniform Traffic Control Devices*) is a railroad crossing sign, consisting of a white reflectorized background with the words "Railroad Crossing" appearing on it in black lettering.

[20] An *active crossing* is a type of highway-rail crossing that has traffic control devices that are activated by the approach or presence of a train, such as flashing light signals, automatic gates, and similar devices, as well as manually operated devices and crossing watchmen, all of which provide motorists positive warning of the approach or presence of a train.

The grade crossing warning devices at this location use a microprocessor-based system (Safetran GCP 3000D2) to calculate the speed of an approaching train and the time it will take for the train to arrive at the crossing. The microprocessor controls the relay logic (crossing control relay) that activates the flashing light units and raises or lowers the gate arms. The system calculates the train's speed and activates the warning devices at a predetermined constant warning time by measuring the rate of change in the approach circuit voltage, the track receiver signal level (EZ current level), and the signal phase relationships. The device provides a relatively uniform warning period (the warning interval length will fluctuate somewhat due to changing ballast and track conditions or variances in the speed of an approaching train). The grade crossing warning devices at the U.S. Route 136 crossing are designed to provide a minimum warning time of 21 seconds for all train speeds up to 79 mph.

The grade crossing predictor at the U.S. Route 136 crossing is equipped with a data recorder (80015 module) and a data recorder interface assembly (80025 module). The 80015 module enables the data recorder to record information associated with train movements through that location. It records the date and time of train movements, the detected train speed,[21] the average train speed,[22] and the island speed.[23] The 80015 module can retain about 3,000 events and record any errors detected by the microprocessor. The data recorder interface assembly (80025 module) enables the data recorder to expand its recording capabilities. The interface assembly can monitor and record voltage level changes from 16 independent inputs. The inputs, connected to relays and the grade crossing predictor unit, are recorded using binary values (on/off, 1/0, or high/low) to signify the relay contact position.

The McLean Police Department provided information on previous instances when it had been dispatched to the U.S. Route 136 grade crossing. The police report information appears in table 1.

[21] The train speed as calculated by microprocessor to determine the warning device activation time.

[22] This was the average speed of the train as it traversed the approach circuit.

[23] Train speed as calculated by microprocessor as the train entered the island circuit, typically at the edge of the paved roadway.

Table 1. McLean Police U.S. Route 136 Crossing Incident Reports

Date	Incident Description
5/16/99	Dispatched to crossing due to vehicle arresting barrier alarm. No problems visible.
5/20/99	Dispatched to crossing by vehicle arresting barrier contractor. No problems visible.
6/4/99	Dispatched to crossing for vehicle arresting barrier alarm. No problems visible.
6/30/99	Vehicle arresting barrier descended on top of car. Driver taken to hospital. (Vehicle driver failed to obey vehicle arresting barrier flashing lights.)
7/9/99	Vehicle arresting barrier stuck in down position after being struck by semi-truck.
7/15/99	Dispatched to crossing for vehicle arresting barrier alarm. No problem found.

The U.S. Department of Transportation accident database contained no entries for previous grade crossing accidents at this crossing.

Vehicle Arresting Barrier. The UP St Louis to Chicago route is a Federally designated emerging high-speed rail corridor and is one of several corridors identified under the Federal Intermodal Surface Transportation Efficiency Act of 1991. Under the Transportation Equity Act for the 21st Century, programs were authorized to aid the States in the development of high-speed rail systems on the designated corridors. The Grade Crossing Hazard Elimination Program was one of the programs authorized under the act to reduce or eliminate highway-rail grade crossing hazards. Grants provided to the States under this program are used to install or improve warning devices; track circuitry for crossing warning devices; crossing surfaces, sight distances, or illumination; physical closures; grade separation construction; advanced train control or intelligent highway traffic control systems; or a combination of these capabilities.

The State of Illinois received a Federal Grade Crossing Hazard Elimination Program grant of $950,000 in 1993 to evaluate and demonstrate a vehicle arresting barrier system. In 1996, the State received an additional grant of $1.5 million to proceed with the demonstration project at three selected highway-rail grade crossings. The Illinois Department of Transportation's Bureau of Railroads selected the three crossings: a rural crossing near Chenoa; an industrial crossing in Hartford; and the U.S. Route 136 mixed use crossing in McLean, to evaluate the mechanical operation of the vehicle arresting barrier. The demonstration project also required evaluation of the annual maintenance; driver response to the barriers; and hardware dependability. The Illinois Department of Transportation contracted with the University of Illinois at Champaign-Urbana to conduct that evaluation. The study concluded on February 28, 2001, when the vehicle arresting

barrier system was taken out of service. (The University of Illinois at Champaign-Urbana is expected to issue a report of the study.)

The vehicle arresting barrier system at the U.S. Route 136 highway-rail grade crossing in McLean was installed on October 30, 1998, and put in service on March 16, 1999. The vehicle arresting barrier system comprises two barriers, one located on either side of the crossing on U.S. Route 136. Each barrier has a net assembly consisting of five horizontal wire cables suspended above the roadway between two towers that are connected by a fixed horizontal rigid truss, also located above the roadway. The towers and connecting truss are equipped with eight 8-inch-diameter red flashing light units for east or westbound traffic on U.S. Route 136. When the vehicle arresting barrier is deployed, the flashing light units are activated and the net assembly is lowered to a position across all lanes of U.S. Route 136. (See figure 4.)

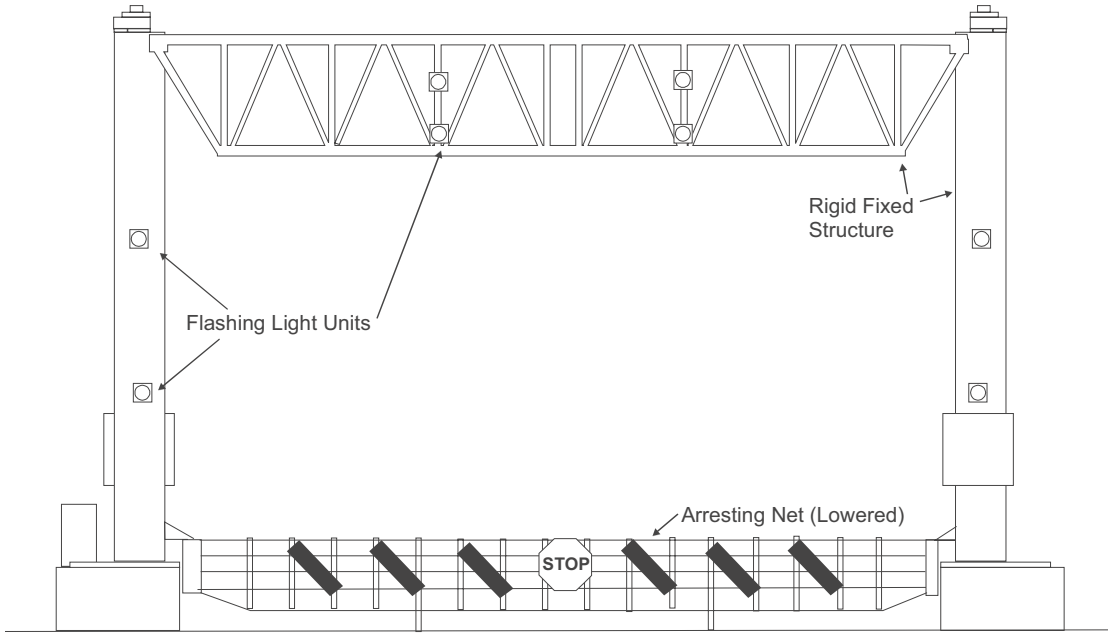

Figure 4. Diagram of vehicle arresting barrier with net lowered and deployed.

The vehicle arresting barrier is interconnected with the railroad warning devices. The grade crossing predictor unit provides an advance preemption that activates the flashing light units on the vehicle arresting barrier about 52 seconds before the arrival of a train at the crossing. In addition to the flashing light units on the vehicle arresting barrier, an advance warning sign (message board)[24] for the vehicle arresting barrier is energized. As the train approaches the crossing, the grade crossing predictor unit activates the flashing light units at the crossing to provide a minimum of 21 seconds of warning. About 5 seconds after the flashing light units on the crossing are activated, the gate arms begin to

[24] Message Board displays: "CROSSING BARRIER AHEAD BE PREPARED TO STOP."

descend. As the gate arms descend, the vehicle arresting barrier nets are also configured to begin descending.

According to the Illinois Department of Transportation high-speed rail manager, the vehicle arresting barrier system at U.S. Route 136 has been repeatedly taken out of service due to incidents. Table 2 lists the reported instances of the vehicle arresting barrier system being taken out of service.

Table 2. Vehicle Arresting Barrier System Out-of-Service Dates

Date	Description of Incident
3/16/99	Truck drove past warning lights on vehicle arresting barrier system and continued past crossing gates and lights that had just activated and struck the opposing barrier net as it was lowering.
5/4/99	Barrier net hooked on the east side as it was clearing roadway.
6/30/99	Driver stopped directly under lowering barrier net.
7/9/99	Truck drove past warning lights on vehicle arresting barrier system, stopped at lowered crossing gate. Truck then backed up into lowered barrier net.
7/16/99	Truck with 6-stall horse trailer drove past warning lights on vehicle arresting barrier system, continued by activated crossing gate and lights and struck opposing lowering barrier net.
9/26/99	Vehicle arresting barrier system was in standby mode since the 7/16/99 incident due to paving of U.S. Route 136 and software updates when accident occurred.

At the time of the September 26, 1999, accident, the vehicle arresting barrier at the U.S. Route 136 crossing was not in service.

Track

The Springfield Subdivision of the UP St. Louis Division is a predominantly single-track main line class 4 track with numerous controlled passing tracks. The Springfield Subdivision, in combination with the Joliet Subdivision, is the UP route between Chicago and St. Louis. This route handles about six freight trains and six Amtrak passenger trains per day. The tracks have timetable speeds of 60 mph for freight trains and 79 mph for passenger trains, with some areas of speed restrictions. Traveling northbound on the Springfield Subdivision in the vicinity of the accident, there is a single-track main with a passing track on the east side that extends 12,430 feet. The UP timetable refers to the passing track as the “McLean siding” and designates its location as milepost 140.9. The U.S. Route 136 highway-rail grade crossing traverses both the main and the siding track, intersecting them at an approximate angle of 37 degrees. The UP designates the location of the crossing as milepost 141.16 on its timetable.

South of U.S. Route 136, the track is tangent (straight) for about 5 miles. Tangent track extends north of the crossing for about 3 miles. At the crossing, the track is nearly level, with a recorded grade of 0.36 percent, descending to the north.

On September 26, 1999, timetable speeds were in effect, with no temporary speed restrictions. The UP had inspected the track 5 days before the accident (on September 21, 1999) and noted no defects.

Postaccident Toxicological Testing

Federal Regulations

Title 49 CFR 219.201 provides the requirements for mandatory postaccident toxicological testing of railroad personnel. Section 219.201(c) requires the railroad representative responding to the scene of the accident to make a good faith determination whether the circumstances of the accident fall under the testing requirements of 49 CFR 219.201(a) or are within the exceptions described in 49 CFR 219.201(b), including:

> 219.201(b) *Exceptions.* No test shall be required in the case of a collision between railroad rolling stock and a motor vehicle or other highway conveyance at a rail/highway grade crossing….

Federal regulations at 49 CFR 219.300 specify conditions under which a railroad is required to submit an employee for mandatory "reasonable suspicion" postaccident testing. Title 49 CFR 219.300(a)(1) and (2) state that:

> 219.300(a)(1) …a railroad shall require a covered employee to submit to an alcohol test when the railroad has reasonable suspicion to believe that the employee has violated any prohibition of subpart B of this part concerning use of alcohol. The railroad's determination that reasonable suspicion exists to require the covered employee to undergo an alcohol test must be based on specific, contemporaneous, articulable observations concerning the appearance, behavior, speech or body odors of the employee.

> 219.300(a)(2) …a railroad shall require a covered employee to submit to a urine drug test when the railroad has reasonable suspicion to believe that the employee has violated any prohibition of subpart B of this part concerning use of controlled substances. The railroad's determination that reasonable suspicion exists to require the covered employee to undergo a drug test must be based on specific, contemporaneous, articulable observations concerning the appearance, behavior, speech or body odors of the employee. Such observations may include indications of the chronic and withdrawal effects of drugs.

Title 49 CFR 219.301(a) authorizes a railroad to conduct postaccident alcohol and drug testing for "reasonable cause." Title 49 CFR 219.301(b)(2) states that reasonable cause breath alcohol testing should be conducted when,

> 219.301(b)(2) …The employee has been involved in an accident or incident reportable under part 225 of this title, and a supervisory employee of the railroad has a reasonable belief, based on specific, articulable facts, that the employee's acts or omissions contributed to the occurrence or severity of the accident or incident.…

Title 49 CFR 219.301(c) states that recognition of the circumstances detailed in 49 CFR 219.301(b)(2) also "…constitutes cause with respect to urine drug testing."

All testing performed under 49 CFR 219.301 is required to be conducted within the time limitations specified in 49 CFR 219.302(b), which states:

> 219.302(b) No employee shall be required to participate in breath alcohol or urine drug testing under this section after the expiration of an eight hour period from —
>
> (1) The time of the observations or other events described in this section; or
>
> (2) In the case of an accident/incident, the time a responsible railroad supervisor[25] receives notice of the event providing reasonable cause for conduct of the test.

UP Drug Testing Policies

The UP adheres to Federal requirements for mandatory postaccident toxicological testing and mandatory reasonable suspicion drug and alcohol testing for safety-sensitive employees covered under FRA regulations.

The UP told the Safety Board that it does not use the authority provided in Federal regulations that allows railroads to conduct reasonable cause testing. Instead, the UP has established the following criteria to conduct reasonable cause testing:

> Union Pacific…. requires reasonable cause drug and alcohol testing of all safety-sensitive employees … when,
>
> - An employee's acts or omissions result in the violation of any safety or operating rule which has the potential to (1) result in an accident and/or personal injury to self or others or (2) actually results in personal injury or significant property damage: or
> - Any other narrowly-circumscribed and verifiable individualized cause has been approved by the General Director-Operating Practices and the Railroad Law Department (e.g. an indictment for violation of the Controlled Substances Act which company investigators verify to be based on reasonably credible evidence).

[25] A supervisor in this context is any responsible line supervisor (such as a trainmaster or road foreman of engines) or superior official in authority over the employee to be tested.

The UP told the Safety Board that its supervisors are provided 3 hours of training concerning postaccident toxicological testing, including testing for cause. The training sessions include the viewing of a training video that addresses signs and symptoms that supervisors should look for in employees when deciding whether to conduct "reasonable suspicion" testing. The training also addresses the types of actions or omissions that would indicate that a supervisor should refer an employee for "reasonable cause" testing. At the conclusion of the training session, each supervisor is given a laminated card, which the supervisor is to keep available at all times, that covers basic postaccident testing information. The UP does not require supervisors to be periodically retrained on postaccident toxicological testing, but some UP departments offer refresher training on this subject.

Toxicological Tests Conducted

Amtrak Crew. No postaccident toxicological testing was conducted on the Amtrak crewmembers.

Automobile Occupants. According to the McLean County Coroner's Office, in the event of an accidental death, homicide, suicide, or suspicious death, the county coroner orders an autopsy. Following the September 26, 1999, accident, the McLean County Coroner's Office ordered autopsies to be performed on both automobile occupants. Postaccident toxicological tests were negative for the presence of alcohol,[26] specified drugs,[27] and carbon monoxide for both automobile occupants.

Signal Maintainer. Following the accident, the UP signal maintainer was not required to undergo toxicological testing by any UP supervisory official. The manager of signal maintenance, who was the signal maintainer's immediate supervisor, evaluated the signal maintainer while at the accident scene. During Safety Board and FRA interviews, the manager of signal maintenance indicated that the signal maintainer exhibited no evidence of drug or alcohol impairment while at the accident scene. Based on his evaluation, the manager of signal maintenance determined not to submit the signal maintainer for drug or alcohol testing.

UP Operating Rules

Maintenance and Testing Requirements

The UP signal tests and standards list all FRA-required monthly, quarterly, and annual tests and inspections that must be performed on highway-rail grade crossing warning equipment. In addition, the UP signal tests and standards include general instructions for maintenance of warning systems. Section 8.1.10 of the *UP Signal Tests*

[26] Ethanol, methanol, acetone, isopropanol, and toluene.

[27] Amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, and phencyclidine.

and Standards Manual[28] discusses, in part, procedures for adjusting grade crossing predictors. It states that:

> A. **Before Adjusting:** Before changing the adjustment on crossing predictors or motion devices, the approach circuits in both directions must be walked, checking the rail, rail bonds, joint coupler termination shunts, correcting any defects.
>
> B. **After Adjusting:** When it is necessary to adjust crossing predictors or motion devices, shunt tests must be made on both approaches to check for the proper warning time for a train moving at maximum speed. A zero ohm shunt is to be placed at 90% of total approach distance and proper operation observed, or a train movement which activates the device accordingly must be observed.

In section 1.2.3 (F) of the *UP Signal Tests and Standards Manual*, the UP gives the following directions about the use of test jumpers:

> Test jumpers will be made of red test lead wire with red vinyl clip insulators. Jumpers will be at least five feet in length. Consideration should be given to limit the number of easily accessible jumpers to enable personnel to make a quick inventory before leaving the test location(s).

This is the only text concerning jumper wire procedures in the UP manual.

The UP defines precautions that must be taken when conducting tests or making changes. Section 1.1.3 of the *UP Signal Tests and Standards Manual* states that the requirements for protection for movement of trains include:

> Maintenance changes or tests, which may interfere with safe operation of trains or other rail movements, must not be started until such movements have been fully protected. Temporary adjustments, when required, must be made in such manner that the safety of trains or other operations will not be impaired. When adjustment, change, or replacement is made, tests must be performed immediately to determine that the apparatus functions as intended. When making tests of the apparatus, the proper instruments must be used and it must be known that no unsafe conditions are set up by the application of testing equipment.

To comply with the requirements of providing protection for the movement of trains, the UP defines procedures in its maintenance-of-way rules. UP maintenance-of-way rule 137.2 states, in part:

> When track, bridge, or signal personnel are working on the track in the approach to a crossing equipped with automatic warning devices, use one of the following methods to protect the public.
>
> 137.2.1 Use one of the following methods to protect the public when working on a single main track.

[28] Union Pacific Railroad, *UP Signal Tests and Standards Manual*, Section 8.1.10 (Union Pacific Railroad, August 1996).

A. Positive Track Authority in Effect (track and time, track warrant, or track permit)

1. No further protection is required because no train movements may be made over the crossing while the employee or gang holds that authority.

B. Form B Track Bulletin in Effect

1. The employee in charge must advise all trains during the clearance that:

   "The automatic crossing warning devices at MP [milepost] ___ are not working properly. You may proceed over the crossing at 15 MPH until the head end of your train completely occupies the crossing."

C. No Positive Track Authority or Form B Track Bulletin in Effect

1. Use a flagger(s) as follows to provide protection: One uniformed law enforcement officer, Two appropriately equipped flaggers.
2. Request a Form C track bulletin that requires trains to proceed over the crossing at 15 MPH until the head end of their train completely occupies the crossing.

137.2.3 When making an emergency repair that causes the warning devices to activate and there are not enough employees to flag the crossing:

1. If no trains can operate over the crossing during the work, then no further protection is required.
2. If trains will operate over the crossing during the work, contact the train dispatcher directly and request that the dispatcher issue a 15 MPH slow order to all affected trains. This may require the dispatcher to contact trains by radio until either: The repair has been made… [or] A Form C track bulletin has been issued.

Postaccident Requirements

The UP instructs its signal maintainers who are tasked to respond to an accident to make the necessary observations and tests to determine the operational status of the crossing warning devices following the accident. These instructions are also included in the UP signal tests and standards for highway-railroad grade crossings. The instructions specify in section 8.1.12 of the *UP Signal Tests and Standards Manual* that upon arrival a maintainer will:

A. Observe conditions at the crossing:

1. Determine from an available witness whether the crossing signals were operating at time of the incident. If practicable, obtain the names and addresses of any persons involved in the incident, and as many witnesses as possible.
2. If vehicle(s) and train(s) are involved in the incident and are still at the crossing, record the location of each and obtain the license number of the

vehicles involved.

3. Inspect the condition of the roadway and rail.
4. Note the weather conditions at the time of the incident, temperature, wind, snow, fog.
5. Determine whether the view in approach of the crossing was blocked by rail cars or other vehicles.

B. If a crossing monitor is in use, disable it from further recording, if practicable, until the data can be printed.

C. Inspect the crossing warning system for damage and make repairs as required.

D. Check the warning system for proper operation as outlined in the Monthly Test Procedure, in addition, shunt each track circuit involved and observe the warning system operates as intended.

E. Notify signal operations and the manager of signal maintenance, reporting all pertinent information about the incident and personally give the manager of signal maintenance the highway crossing warning report. This report will be kept in the manager of signal maintenance's file until legal matters are settled.

Signal Maintainer Training

UP employee records indicated that the signal maintainer was provided with training related to the requirements of his job. Employee records indicated that the signal maintainer had most recently attended training in the following subjects:

Training	Date
Signal circuit wiring and testing	2/11/99
On-track safety training	3/23/99
Maintenance-of-way training update	3/23/99

According to Safety Board and FRA interview statements, the Safetran grade crossing predictor 3000 unit was installed at the U.S. Route 136 crossing about 18 months before the accident. The signal maintainer did not receive hands-on training concerning the grade crossing predictor 3000 equipment; he attended training along with other signal personnel on the manager of signal maintenance's territory in March 1998 regarding the use of the Safetran manual provided for the grade crossing predictor 3000 equipment. The information in the manual did not address how jumper wires should be used or applied during recalibration of the grade crossing predictor.

Within the Bloomington territory, the signal maintainer is responsible for 21 highway-rail grade crossings with active warning devices. Eleven of the 21 crossings have Safetran grade crossing predictor 3000 equipment, 5 have Safetran grade crossing

predictor 600 equipment, 1 is equipped with motion sensor equipment, 2 have phase shift overlay equipment, 1 is equipped with DC circuits, and 1 is equipped with Ring 10 equipment.

When the Safety Board asked the manager of signal maintenance about the use of jumper wires during crossing maintenance, he said that when he did such work he usually disabled only the crossing gates (keeping them in the raised position), while allowing the flashing lights to activate to warn motorists of train movements.

Postaccident Tests

Visibility and Sight Distance

According to the American Association of State Highway and Transportation Officials, for a vehicle approaching a crossing, the driver must be able to see a train far enough along the tracks to have time to react to its presence and stop the highway vehicle before the crossing. The quadrant sight distance or "sight triangle" is formed by the distance along the roadway, the distance along the railroad tracks, and the distance along an imaginary line from the train to the highway vehicle. At the U.S. Route 136 crossing, the signal case and a small clump of low vegetation near the track were within the sight triangle. (See figure 5.)

Figure 5. View down tracks from accident vehicle's direction of travel.

According to State police reports, no tire marks from the highway vehicle were found on the pavement approaching the crossing. The video monitoring system[29] indicated that the brake lights on the automobile never activated as it approached the crossing.

[29] See discussion in the "Event Recorder – Vehicle Arresting Barrier" section.

Railroad Signals

The UP railroad traffic control signal system was evaluated after the accident. The review indicated that the railroad traffic control signal system displayed the proper aspect sequence for train movements. The system did not display conflicting signals for Amtrak train 304-26.

Grade Crossing Signals

In the hours after the accident, the U.S. Route 136 grade crossing warning system was tested in the presence of representatives from the FRA, the UP, the Illinois Commerce Commission, and the Illinois State Police. Complete operational testing of the warning system was performed, including testing of all relays and cables. All calibration settings for the equipment were verified for compliance with manufacturer, UP, and Federal specifications. On September 27, 1999, the system was again completely tested twice. No corrective action was deemed necessary on any of the equipment. The UP signal technician stated that he tested the crossing control relay about a dozen times after the accident and found the results to be within the manufacturer's specifications. The crossing control relay was left in service after the September 27 testing.

Event Recorders

Amtrak Locomotive. Data from the event recorder on the Amtrak train 304-26's locomotive were downloaded on September 27, 1999 in Chicago. The recorder data indicated Amtrak train 304-26 was traveling 74 mph just before the air brake pipe pressure dropped to zero (emergency brake application). The recorder data also showed that the train's headlight was on and its horn was sounded as the train approached the U.S. Route 136 crossing. The data indicated that the Amtrak train took about 50 seconds from the initiation of the emergency brake application to stop.

Grade Crossing Predictor. The grade crossing predictor data recorder was downloaded on the evening of the accident. The recorder indicated four train movements between 3:00 a.m. and 12:05 p.m. on September 26. The data also indicated that at 2:18 p.m., a recalibration of the grade crossing predictor unit was performed. The data indicated that the crossing control relay remained energized during the recalibration. Following the recalibration, the recorder showed no evidence of operational testing being conducted on the equipment and no train movements through the crossing until northbound Amtrak train 304-26. The data indicated the following events:

Time[30]	Event
5:07:19	Preemption for vehicle arresting barrier advance warning lights
5:08:11	Island circuit on main track indicates occupied
5:08:15	Island circuit on main track indicates unoccupied

[30] Times are in accordance with the grade crossing predictor clock.

The data recorder showed the crossing control relay as energized while the Amtrak train went through the crossing. The relays controlling the gates and lights were recorded as remaining energized.

Vehicle Arresting Barrier. The vehicle arresting barrier system was equipped with a data event recorder and a video monitoring system. Both the event recorder and the video were configured to allow captured information to be downloaded remotely.

Although the vehicle arresting barrier system was in standby mode[31] and not operating at the time of the accident, its event recorder was functioning and recording the advance preemption that would signal the vehicle arresting barrier system to activate the advance warning lights and the simultaneous preemption that would start the barrier nets descending. After 2:16 p.m.[32] on September 26 (when the grade crossing predictor unit was recalibrated), the event recorder captured the following events:

Time[33]	Event
2:16:11	Advance preemption signal received from grade crossing predictor unit (grade crossing predictor recalibration)
2:17:30	Advance preemption signal no longer received from grade crossing predictor unit (grade crossing predictor recalibration)
5:06:39	Advance preemption signal received from grade crossing predictor unit (train 304-26)
5:07:38	Advance preemption signal no longer received from grade crossing predictor unit (train 304-26)
9:19:10	Advance preemption signal received from grade crossing predictor unit (1st train move following accident)
9:19:18	Simultaneous preemption signal received from grade crossing predictor unit
9:21:05	Simultaneous preemption signal no longer received from grade crossing predictor unit
9:21:05	Advance preemption signal no longer received from grade crossing predictor unit

[31] When the vehicle arresting barrier is in standby mode, the vehicle arresting barrier flashing lights will not activate and the barrier nets will not lower.

[32] When investigators reviewed the data from the respective event recording devices, they found that the vehicle arresting barrier clock was approximately 2 minutes slower than the grade crossing predictor clock. (The accident time of 5:08 p.m. used throughout this report and by the FRA, the State police, and the coroner was obtained from the grade crossing predictor clock.)

[33] Times are in accordance with vehicle arresting barrier recorder clock.

Six video cameras are positioned to record highway vehicles approaching the vehicle arresting barrier structure and the railroad tracks from either direction on U.S. Route 136. The video recorder is activated by the approach of a train, and it records for a predetermined interval (about 120 seconds) before automatically deactivating. Images from the day of the accident were downloaded from the video monitoring system.

The vehicle arresting barrier video recorder recorded an image at 5:06 p.m. of Amtrak train 304-26 approaching the crossing. Additional video images indicated that both crossing gates were in the vertical (90º) position and all flashing light units were inactive at this time.

Other Information

Some U.S. railroads require signal personnel to request authority from a supervisory signal official whenever they use jumper wires on signal equipment and require them to notify the train dispatcher so a notation can be made with all necessary information about the signal equipment involved. In such cases, the dispatcher keeps the notation open until the person authorized to use the jumper wires reports that normal conditions have been restored.

Specialized electronic rack units are available to store jumper wires on maintenance vehicles used by signal personnel. The rack units notify signal personnel when a jumper wire is missing with an audible alarm and a visual red light alarm. The vehicles used by UP signal personnel were not equipped with such units.

Analysis

This analysis consists of three main sections. The first identifies factors that can be eliminated as causal or contributory to the accident. The second reviews the accident itself, highlighting the actions and events that resulted in problem conditions. In the third section of the analysis, the Safety Board examines the UP's signal maintenance procedures, the UP's postaccident site securement procedures for highway-rail grade crossing accidents, and postaccident toxicological testing issues arising from the accident investigation. This section also addresses concerns identified during the investigation regarding the FRA's accident database.

General

Nothing in the Amtrak train's pre-trip mechanical and air brake tests, the postaccident inspection of the train, or the data from the locomotive event recorder indicated that an equipment malfunction affecting train 304-26 occurred. Postaccident inspections revealed no track defects in the accident area, and crewmembers did not refer to track conditions as a concern.

At the time of the accident, the weather was dry, with visibility at 15 miles and scattered cloud cover.

A postaccident railroad signal evaluation revealed that the UP railroad traffic control signal system displayed the proper aspect sequence for train movements and did not display conflicting signals for Amtrak train 304-26.

Members of the Amtrak train crew had taken the required operating and safety rules classes in the past year. In addition, the Amtrak engineer had successfully completed all training requirements and tests for certification as a locomotive engineer. The Safety Board found no performance deficiencies on the part of the train crewmembers in their efforts to stop the train, avoid the collision with the automobile, or respond to the accident.

No evidence indicated that either highway vehicle occupant had been taking prescription or nonprescription medications or illicit drugs that could have affected their performance. No evidence indicated that they were under the influence of alcohol. Both occupants had been in good health and had normal vision and hearing.

Accident Discussion

On September 26, 1999, about 5:08 p.m., northbound Amtrak train 304-26, which was en route from St. Louis, Missouri, to Chicago, Illinois, collided with an automobile,

which was westbound on U.S. Route 136. The collision occurred at the highway-rail grade crossing where the UP's St. Louis Division main line and U.S. Route 136 cross near the town of McLean, Illinois.

A signal maintainer had recalibrated the railroad grade crossing predictor at the U.S. Route 136 grade crossing about 2:18 p.m. on the day of the accident. When it is operating normally and without intervention, a crossing control relay is energized unless its associated crossing warning system detects the approach of a train. When the crossing detection system detects a train, it automatically de-energizes the crossing control relay, which causes the crossing's flashing lights and gates to activate. The signal maintainer stated that in the hours preceding the accident, to avoid interrupting highway traffic while he went through the calibration process, he interfered with the routine operation of the relay by using a jumper wire to keep the crossing control relay artificially energized during the recalibration. By falsely energizing the relay, the maintainer was circumventing the crossing warning system's ability to activate the crossing's flashing lights and gates. The signal maintainer completed the recalibration of the grade crossing predictor and left the area about 4:30 p.m. Grade crossing predictor data logs showed that the crossing control relay remained energized throughout the recalibration process, after the recalibration was performed, and during the accident.

About 5:07 p.m. on the day of the accident, the grade crossing predictor detected a northbound train (Amtrak train 304-26) approaching the U.S. Route 136 crossing. Data recorded by the grade crossing predictor showed that preemption signals were sent to the vehicle arresting barrier equipment, which activated its video monitoring system. The data recorded also showed that the crossing control relay remained energized, which prevented the grade crossing warning devices from activating. The video recording verified that, as Amtrak train 304-26 approached the crossing, both gates remained in the "up" position, and the flashing light units remained dark. Five accident witnesses later told police that the crossing warning devices did not activate for Amtrak train 304-26.

The Safety Board considered whether an equipment malfunction might have caused the failure of the crossing warning system to activate. Analysis of the data from the grade crossing recording equipment and the vehicle arresting barrier data recorder and video monitoring system indicated that before the accident, the grade crossing warning system was detecting train movements as designed. The system correctly detected and recorded train movements earlier in the day on September 26, 1999. The system also detected and recorded the approach of Amtrak train 304-26 just before the accident occurred. Complete operational tests of the grade crossing warning system were conducted several times during the postaccident investigation. The testing did not identify any deficiencies that would have prevented proper operation of the system. The crossing control relay was subjected to repeated testing following the accident. All tests indicated that the relay was operating within the manufacturer's specifications, and no deficiencies were identified that would have caused the relay to remain stuck in the energized position.

During postaccident FRA interviews, the signal maintainer stated that he thought he remembered removing the jumper wire that he had used to falsely energize the crossing control relay before he left the U.S. Route 136 grade crossing about 4:30 p.m. However,

the manager of signal maintenance stated that when he and UP attorneys spoke with the signal maintainer on the day after the accident, the signal maintainer admitted that he "must have" left the jumper wire on the relay.

After the accident, train movements through the crossing were simulated to recreate the accident events. The simulations indicated that the only way to recreate the data that appeared in the grade crossing predictor data log from the day of the accident was to simulate a train movement while a jumper wire was in place to artificially energize the crossing control relay. The Safety Board therefore concludes that although the grade crossing warning system at U.S. Route 136 detected the approach of Amtrak train 304-26, the flashing lights and gates were prevented from activating because the signal maintainer had not removed the jumper wire that he had used to falsely energize the crossing control relay during the recalibration of the equipment.

Evidence suggests that the occupants of the westbound vehicle crossing the train tracks about 5:08 p.m. on September 26, 1999, were unaware of Amtrak train 304-26's proximity until just before impact. Although the sight distance from the vehicle to the train was essentially unimpeded, the vehicle did not accelerate, take any evasive maneuvers to avoid the collision, or leave tire marks on the pavement that would have indicated an attempt to stop.

At the U.S. Route 136 grade crossing, in addition to the normal warning devices for the crossing, the accident vehicle encountered the advance warning sign (message board) for the vehicle arresting barrier and the vehicle arresting barrier itself. However, because the vehicle arresting barrier equipment was in standby mode, it provided no warning of the approaching train.

Although the sight distance between the crossing and the train was clear enough that the approaching train could have been seen by the vehicle occupants, they apparently did not notice it before they proceeded across the tracks. The Safety Board concludes that because neither the crossing warning system nor the vehicle arresting barrier devices gave any indication of the approach of Amtrak train 304-26, the vehicle driver was not provided these active visual cues that it was unsafe to continue across the railroad tracks.

Accident and Postaccident Safety Factors

UP Signal Maintainer Performance

During its investigation, the Safety Board found that, in addition to leaving the jumper wire on the crossing control relay on the day of the accident, the UP signal maintainer did not perform his work near the U.S. Route 136 grade crossing in accordance with UP rules. First, in a deviation from UP rules, the signal maintainer failed to obtain authority from the dispatcher while he worked on the track connection to provide protection against train movements for himself and for highway vehicles crossing the

tracks while the crossing gates and lights were disabled by the false energizing of the crossing control relay.

The signal maintainer further deviated from the railroad's rules by not performing operational tests, as required by the UP, on the grade crossing warning devices at the U.S. Route 136 crossing after he recalibrated the grade crossing predictor. Data from the grade crossing event recorder and the video monitoring system confirm that no operational tests were conducted on the crossing warning system after the recalibration.

Had the signal maintainer performed these operational tests of the grade crossing equipment after the recalibration, he would have detected the failure of the warning devices to activate. Thus alerted, he would have rectified the situation by removing the jumper wire from the crossing control relay, which would have left the grade crossing warning devices capable of activating when a train was detected. Consequently, the Safety Board concludes that because the signal maintainer failed to fulfill the UP's requirement to conduct operational tests on the grade crossing warning devices after he performed a recalibration of the grade crossing predictor, he did not realize that the jumper wire was still attached to the crossing control relay.

Employee training records indicate that the signal maintainer was qualified under roadway worker protection requirements, signal test and maintenance procedures, and on-track safety requirements. UP records indicate that the signal maintainer had attended training in these subjects within the year before the accident. Nevertheless, despite the signal maintainer's training and qualifications, he did not follow UP company safety procedures concerning post-calibration operational testing, with ultimately disastrous results.

The Safety Board attempted to determine why the signal maintainer, who had worked in railroad signal departments for more than 30 years, was qualified and trained, and had a relatively good disciplinary record, made the errors he made on the day of the accident. Unfortunately, because the signal maintainer would not give Safety Board investigators his account of the events that led to the accident or information about his activities in the days preceding the accident, the Safety Board had insufficient information to determine possible reasons for the signal maintainer's errors. The Safety Board also could not establish whether the signal maintainer might have been under the influence of drugs or alcohol when he carried out his work on the day of the accident, because no postaccident drug or alcohol testing was conducted on the signal maintainer. (This issue will be addressed later in the analysis.)

The Safety Board appreciates that signal personnel are required at times to conduct their work at grade crossings under heavy traffic without the aid of flagmen to provide highway traffic control. Although undesirable, these situations often require signal personnel to use jumper wires to totally or partially disable the grade crossing warning devices. The Safety Board considers, however, that means are available that would make the use of jumper wires in such situations safer and more regimented.

Some railroads provide their signal personnel with maintenance vehicles equipped with specialized electronic rack units that are designed to notify signal personnel when a jumper wire is missing from the rack with both an audible warning alarm and a visual light signal. These warning systems provide a double-checking mechanism that helps the railroad safeguard against its employees leaving jumper wires in unsafe locations.

Such warning equipment provides an automatic and reliable means of ensuring that signal employees keep track of the jumper wires they use on the job, thus offsetting human errors caused by distraction, habit, or carelessness. By using such equipment, the railroad can greatly reduce the possibility of a jumper wire being left in an unsafe location, as occurred in the McLean accident. The Safety Board concludes that had the UP provided its signal personnel with automatic warning equipment that alerted them when they failed to retrieve all jumper wires before leaving a work location, the signal maintainer would not have left the U.S. Route 136 grade crossing without removing the jumper wire that was still attached to the crossing control relay. Therefore, the Safety Board believes that the UP should provide its signal maintenance personnel with dedicated jumper wire warning systems or other equipment that will automatically alert them if they attempt to leave a work site without retrieving all jumper wires they have used at that location. Also, because ensuring that jumper wires are removed from unsafe locations is important to the signal maintenance personnel of all railroads, the Safety Board believes that the Brotherhood of Railroad Signalmen should inform its members of the circumstances of this accident and emphasize the importance of conducting operational tests and accounting for all jumper wires after performing maintenance or repair tasks.

UP Postaccident Procedures at Highway-Rail Grade Crossings

After being notified of the collision, the UP had the signal maintainer and the signal technician for this location contacted and called to the accident scene. When he arrived at the scene, the signal maintainer, who had earlier that day recalibrated the grade crossing predictor, entered the signal case for the U.S. Route 136 grade crossing by himself, while the signal technician went to assess damages at the crossing. Some time later, the signal technician joined the signal maintainer in the signal case. Subsequently, State police, at the request of the deputy coroner, asked the two railroad employees to exit the signal case until the accident reconstructionist (the deputy coroner) gave them authorization to begin testing the equipment. No one reported finding a jumper wire attached to the crossing control relay after the signal maintainer left the signal case, despite the fact that the event recorder and simulations evidence strongly indicated that a jumper wire had been on the crossing control relay when the accident occurred.

Because the work done on the signals earlier in the accident day had a direct bearing on the accident, the fact that the signal maintainer was the first person to enter the signal case and had unsupervised control of the case for some time could have created a perception that the signal evidence was not being preserved as professionally as possible. The Safety Board is concerned that such instances could be detrimental to an effective investigative process. Consequently, the Safety Board concludes that the UP's failure to secure the signal case immediately after the accident compromised the integrity of the accident investigation.

The UP manager of signal maintenance who supervised the signal personnel dispatched to the McLean accident scene has stated that, based on the lessons he learned in the aftermath of this accident, he now sends a signal maintainer from a neighboring territory to respond to any reported grade crossing accident. The Safety Board finds this a prudent step but considers that the UP can and should make a greater effort to guarantee the integrity of the postaccident procedures necessary to all grade crossing accident investigations. Therefore, the Safety Board believes that the UP should establish procedures to immediately secure the signal case associated with any grade crossing accident until an appropriate, authorized UP or government official is on the scene to supervise entry to the signal case.

Postaccident Toxicology Testing

All the Amtrak train crewmembers were exempt from FRA mandatory postaccident toxicological testing of railroad personnel because of the exemption in 49 CFR 219.201(b), which states that "No test shall be required in the case of a collision between railroad rolling stock and an automobile or other highway conveyance at a rail/highway grade crossing." Under the same exemption for railroad personnel, mandatory postaccident testing requirements did not apply to the UP signal maintainer.

The UP could have required the signal maintainer to undergo toxicological testing for "reasonable suspicion" under Federal regulations if specific appearances or behaviors were observed. Reasonable suspicion alcohol and drug testing (as detailed in 49 CFR 219.300) must be conducted when a railroad has reason to believe, based on observation of the employee's appearance, behavior, speech, and other physical factors, that an employee may be under the influence of alcohol or controlled substances. The UP manager of signal maintenance evaluated the signal maintainer while at the accident scene and considered that the signal maintainer exhibited no evidence of drug or alcohol impairment at that time. Based on his evaluation, the manager of signal maintenance decided not to require the signal maintainer to undergo reasonable suspicion drug or alcohol testing.

The UP could also have required the signal maintainer to be tested for drugs or alcohol based on "reasonable cause," as authorized at 49 CFR 219.301 and under the UP's reasonable cause drug and alcohol testing provisions. The Federal regulations describe reasonable cause for breath alcohol testing (49 CFR 219.301[b][2]) and urine drug testing (49 CFR 219.301[c]) as

> The employee has been involved in an accident or incident… and a supervisory employee of the railroad has a reasonable belief, based on specific, articulable facts, that the employee's acts or omissions contributed to the occurrence or severity of the accident or incident….

Similarly, the UP's reasonable cause provisions call for reasonable cause testing to be conducted when

> An employee's acts or omissions result in the violation of any safety or operating rule which has the potential to (1) result in an accident and/or personal injury to self or others or (2) actually results in personal injury or significant property damage….

In the case of the McLean accident, during the immediate aftermath of the accident, several witnesses stated that the crossing warning devices at the U.S. Route 136 crossing did not activate as Amtrak train 304-26 approached the crossing. At 7:18 p.m., the crossing event recorder data were downloaded in the presence of the UP manager of signal maintenance. The recorder data showed that a recalibration of the equipment had been performed earlier in the day. The data further showed that no operational tests had been performed on the equipment following the recalibration, as was required by UP rules. The UP manager of signal maintenance stated that around this time, the signal maintainer told him that he had performed the recalibration and worked on the U.S. Route 136 crossing equipment earlier that day.

The Safety Board considers that the postaccident events indicating problems with the U.S. Route 136 grade crossing equipment, coupled with the knowledge that the signal maintainer had worked on this equipment earlier in the day and had broken the UP rule calling for operational tests to be conducted after he had finished the work, should have caused the UP officials to invoke the UP reasonable cause testing requirement. Because this requirement calls for testing to be performed when an employee has violated a safety or operating rule that has the potential to result in an accident, the signal maintainer's violation of the operational testing rule, which was known to UP officials after the event recorder data had been downloaded, should have triggered reasonable cause testing of the signal maintainer. The Safety Board therefore concludes that the UP should have submitted the signal maintainer for reasonable cause toxicological testing but failed to do so.

This accident was unusual in that, because the crossing event recorder was downloaded shortly after the accident occurred, the UP had nearly immediate evidence of a rule violation. Under many, if not most, circumstances, this information would not have been so readily available to the railroad. In the confusion and disorder that follow most accidents, it might take many hours or even days before the railroad has evidence (such as that provided by event recorder data) of a rule violation with bearing on the accident.

Drug and alcohol testing must be conducted in a timely fashion or the results of the testing become meaningless. Federal regulations (49 CFR 219.302[b]) recognize the importance of timeliness in testing and state that

> No employee shall be required to participate in breath alcohol or urine drug testing… after the expiration of an eight hour period….

Under most postaccident circumstances, therefore, even if the UP applied its reasonable cause testing requirement scrupulously, the testing might not be conducted within 8 hours of the accident, so the results of the testing would be of limited value to the investigation.

The Safety Board, however, has more far-reaching concerns about the application of postaccident drug testing for grade crossing accidents. As already noted, Federal regulations at 49 CFR 219.201(b) exempt all railroad personnel from mandatory postaccident testing requirements in the case of an accident involving a highway-rail grade crossing. The Safety Board appreciates that this exemption was provided because most grade crossing accidents are not caused by the actions or omissions of train crew personnel. The circumstances of this accident, however, suggest that such a broad exemption may be imprudent. For example, in this accident, the railroad signal maintainer, whose actions had a direct bearing on the cause of the accident, was automatically exempted from mandatory postaccident testing requirements.

Although the Safety Board recognizes that train crew personnel may not need to be tested following a grade crossing accident, it considers that, in some cases, other railroad personnel should be tested. There are a variety of circumstances in which errors on the part of railroad maintenance personnel might affect the rail equipment or conditions so that a grade crossing accident results. But because of the exemption at 49 CFR 219.201(b), such personnel are excused from postaccident testing following grade crossing accidents, regardless of the accident circumstances.

Because the UP signal maintainer, who was the person most responsible for the McLean accident, was exempt from mandatory postaccident drug and alcohol testing requirements and was not tested for drug or alcohol use, the Safety Board concludes that exempting all railroad personnel from mandatory postaccident drug and alcohol testing following a grade crossing accident has the potential to exclude from testing obligations some railroad employees whose actions may have significantly contributed to the occurrence or severity of an accident. Exempting all such employees from postaccident testing obligations greatly increases the likelihood that no postaccident drug and alcohol testing will be performed on them in a timely fashion, and the lack of this information could impede future accident investigations. Therefore, the Safety Board believes that the FRA should modify 49 CFR 219.201(b) as necessary to ensure that the exemption from mandatory postaccident drug and alcohol testing for those involved in highway-rail grade crossing accidents does not apply to any railroad signal, maintenance, and other employees whose actions at or near a grade crossing involved in an accident may have contributed to the occurrence or severity of the accident.

FRA Accident Database

The Safety Board determined that after the McLean accident, Amtrak and the UP submitted the required "Rail Equipment Accident/Incident" and "Highway-rail Grade Crossing Accident/Incident" reports to the FRA in accordance with Federal requirements. The FRA made these reports accessible to the public through the FRA website. The UP's initial report indicated that the primary cause of the accident had been vehicle driver inattentiveness. Amtrak's initial report indicated that the accident had been caused by the vehicle being driven around or through the gate at the crossing.

At the conclusion of its subsequent investigation of the McLean accident, the FRA found that the probable cause of the accident was not driver inattentiveness or wrongdoing

but the fact that the crossing control relay remained falsely energized during the approach and passage of Amtrak train 304-26. The FRA issued violations to both the UP and Amtrak for failing to submit revised accident/incident reports to the FRA after the cause of the accident became known to them. Nevertheless, the initial UP and Amtrak reports, with their inaccurate probable cause statements, remained available through the FRA website for a number of months after the actual circumstances of the accident became known.

The grade crossing accident database information available through the FRA website forms the factual and statistical basis for numerous studies and investigations involving grade crossing safety issues. As a frequent user of the FRA accident database, the Safety Board is concerned with ensuring that the information available from it is consistently reliable and current. The Safety Board recognizes that it is difficult, given the technical and budgetary demands of database and website maintenance, to ensure that all data available through a website are up to date at all times. But preserving and publishing outdated or incorrect information greatly reduces the value and reputation of such a database and could skew the results of studies that draw on database information. Poor information can also negatively affect the safety decisions that are reached based on research involving FRA database information. Consequently, the Safety Board encourages the FRA to make the updating and maintenance of its accident database information a priority.

Conclusions

Findings

1. Although the grade crossing warning system at U.S. Route 136 detected the approach of Amtrak train 304-26, the flashing lights and gates were prevented from activating because the signal maintainer had not removed the jumper wire that he had used to falsely energize the crossing control relay during the recalibration of the equipment.

2. Because neither the crossing warning system nor the vehicle arresting barrier devices gave any indication of the approach of Amtrak train 304-26, the vehicle driver was not provided these active visual cues that it was unsafe to continue across the railroad tracks.

3. Because the signal maintainer failed to fulfill the Union Pacific Railroad's requirement to conduct operational tests on the grade crossing warning devices after he performed a recalibration of the grade crossing predictor, he did not realize that the jumper wire was still attached to the crossing control relay.

4. Had the Union Pacific Railroad provided its signal personnel with automatic warning equipment that alerted them when they failed to retrieve all jumper wires before leaving a work location, the signal maintainer would not have left the U.S. Route 136 grade crossing without removing the jumper wire that was still attached to the crossing control relay.

5. Union Pacific Railroad's failure to secure the signal case immediately after the accident compromised the integrity of the accident investigation.

6. The Union Pacific Railroad should have submitted the signal maintainer for reasonable cause toxicological testing but failed to do so.

7. Exempting all railroad personnel from mandatory postaccident drug and alcohol testing following a grade crossing accident has the potential to exclude from testing obligations some railroad employees whose actions may have significantly contributed to the occurrence or severity of an accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the signal maintainer to remove a jumper wire from the grade crossing control relay and, as required by the Union Pacific Railroad's written procedures, to verify the operational status of the grade crossing equipment after he had completed the maintenance work.

Recommendations

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

To the Federal Railroad Administration

Modify 49 *Code of Federal Regulations* 219.201(b) as necessary to ensure that the exemption from mandatory postaccident drug and alcohol testing for those involved in highway-rail grade crossing accidents does not apply to any railroad signal, maintenance, and other employees whose actions at or near a grade crossing involved in an accident may have contributed to the occurrence or severity of the accident. (R-01-17)

To the Union Pacific Railroad

Provide your signal maintenance personnel with dedicated jumper wire warning systems or other equipment that will automatically alert them if they attempt to leave a work site without retrieving all jumper wires they have used at that location. (R-01-18)

Establish procedures to immediately secure the signal case associated with any grade crossing accident until an appropriate, authorized Union Pacific Railroad or government official is on the scene to supervise entry to the signal case. (R-01-19)

To the Brotherhood of Railroad Signalmen

Inform your members of the circumstances of the September 26, 1999, grade crossing accident in McLean, Illinois, and emphasize the importance of conducting operational tests and accounting for all jumper wires after performing maintenance or repair tasks. (R-01-20)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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