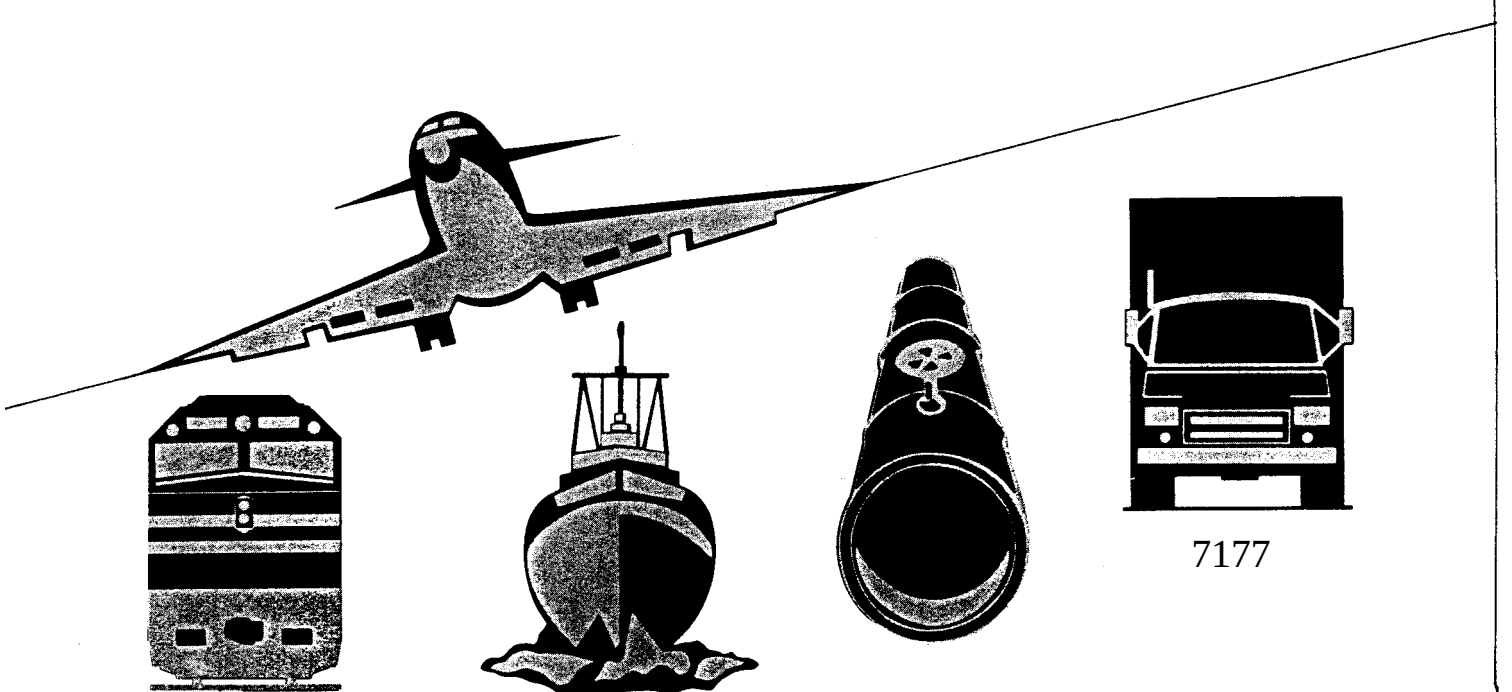
PB99-916302
NTSB/RAR-99/02

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

**COLLISION OF
NORFOLK SOUTHERN CORPORATION TRAIN 255L5 WITH
CONSOLIDATED RAIL CORPORATION TRAIN TV 220
BUTLER, INDIANA
MARCH 25, 1998**



7177

National Transportation Safety Board. 1999. *Collision of Norfolk Southern Corporation Train 255L5 With Consolidated Rail Corporation Train TV 220 in Butler, Indiana, on March 25, 1998.* Railroad Accident Report NTSB/RAR-99/02. Washington, DC.

Abstract: On March 25, 1998, about 4:48 a.m. eastern standard time, southbound Norfolk Southern Corporation (Norfolk Southern) train 255L5, which was en route to Fort Wayne, Indiana, struck eastbound Consolidated Rail Corporation (Conrail) train TV 220, which was en route to Columbus, Ohio. The Norfolk Southern conductor was killed; the engineer and student engineer sustained minor injuries. The two Conrail crewmembers were not injured.

The safety issues discussed in this report are the adequacy of Norfolk Southern's methods for ensuring compliance with the operating rules, the adequacy of Norfolk Southern's locomotive engineer training program, and the importance of train crew resource management to safe and efficient train operations.

As a result of its investigation, the National Transportation Safety Board issued recommendations to the Federal Railroad Administration, Norfolk Southern Corporation, the Class I railroads and Amtrak, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, the United Transportation Union, Harmon Industries, and the DeKalb County Emergency Management Agency.

Railroad Accident Report

Collision of
Norfolk Southern Corporation Train 255L5 With
Consolidated Rail Corporation Train TV 220
Butler, Indiana
March 25, 1998

NTSB/RAR-99/02
PB99-916302
Notation 7177
Adopted: July 13, 1999

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

this page intentionally left blank

Contents

Executive Summary v

Factual Information 1
Accident Narrative 1
Preaccident Events—Conrail 1
Preaccident Events—Norfolk Southern 5
The Accident 9
Damage 10
Postaccident Events 11
Train Crew Information 12
Conrail Crewmembers 12
Norfolk Southern Crewmembers 12
Track and Site Information 14
Norfolk Southern Operating Rules 15
Postaccident Tests 17
Visibility and Sight Distance 17
Signals 18
Norfolk Southern Signal Malfunction Reporting 20
Locomotive Engineer Training Program 21
Crew Communication 23

Analysis 24
Exclusions 24
Accident Discussion 25
Adequacy of Methods for Ensuring Compliance With Operating Rules 27
Adequacy of the Locomotive Engineer Training Program 29
Importance of Train Crew Resource Management 32
Adequacy of Signal Malfunction Reporting Procedures 33
Continued Need for In-Cab Audible Recording Devices on Trains 35
Importance of Emergency Response Management in Hazardous Materials Accidents 36

Conclusions 38
Findings 38
Probable Cause 40

Recommendations 41

Appendixes 49
A: Harmon Industries Bulletin on Electro Code 4 Units 49
B: Norfolk Southern Lake Division Student Engineer Form 51
C: UP signal Recording Form 52

Acronyms and Abbreviations 53

this page intentionally left blank

Executive Summary

On March 25, 1998, about 4:48 a.m. eastern standard time, southbound Norfolk Southern Corporation (Norfolk Southern) train 255L5, which was en route to Fort Wayne, Indiana, struck eastbound Consolidated Rail Corporation (Conrail) train TV 220, which was en route to Columbus, Ohio. The collision occurred where the Norfolk Southern Huntington District and the Conrail Chicago main lines cross at grade at the east end of the town of Butler, Indiana. Both locomotives and five cars from the Norfolk Southern train derailed, and three cars from the Conrail train, two with multiple stacked platforms, derailed. The Norfolk Southern conductor was killed; the engineer and student engineer sustained minor injuries. The two Conrail crewmembers were not injured.

No hazardous materials were released, but both Norfolk Southern locomotive fuel tanks ruptured and released approximately 7,000 gallons of fuel oil. Norfolk Southern estimated total damages of $264,000 ($187,000 to equipment, $18,000 to track and signals, and $59,000 to cargo). Conrail estimated total damages of $352,200 ($314,000 to equipment, $33,500 to track and signals, and $4,700 to cargo).

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer and conductor of train 255L5 to comply with operating rules (specifically, their failure to observe and confirm signal aspects and their failure to continuously and directly supervise the student engineer) and the failure of Norfolk Southern Corporation to ensure employees' compliance with operating rules. Contributing to the accident was Norfolk Southern Corporation's failure to ensure that its locomotive engineer training program provided effective, timely training; oversight; and feedback to ensure that students were adequately prepared for operational situations. Also contributing to the probability of this accident occurring was the failure of Norfolk Southern Corporation's signal maintenance program to respond to a reported signal deficiency.

As a result of its investigation of this accident, the Safety Board identified the following major safety issues:

- Adequacy of Norfolk Southern's methods for ensuring compliance with the operating rules,
- Adequacy of Norfolk Southern's locomotive engineer training program, and
- Importance of train crew resource management to safe and efficient train operations.

The analysis also addresses additional safety concerns identified during the investigation: the adequacy of Norfolk Southern's signal malfunction reporting procedures and of Harmon Industries' signal component repair and replacement program, the continued need for in-cab audible recording devices on trains to provide essential

details for accident investigations, and the importance of emergency response management in railroad accidents involving hazardous materials.

As a result of its investigation of this accident, the Safety Board makes recommendations to the Federal Railroad Administration, Norfolk Southern Corporation, the Class I railroads and Amtrak, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, the United Transportation Union, Harmon Industries, and the DeKalb County Emergency Management Agency.

Factual Information

Accident Narrative

On March 25, 1998, about 4:48 a.m.,[1] southbound Norfolk Southern Corporation (Norfolk Southern)[2] train 255L5, which was en route to Fort Wayne, Indiana, struck eastbound Consolidated Rail Corporation (Conrail)[3] train TV 220, which was en route to Columbus, Ohio. The collision occurred where the Norfolk Southern Huntington District and the Conrail Chicago main lines cross at grade at the east end of the town of Butler, Indiana. (See figures 1 through 3.) Both locomotives and five cars from the Norfolk Southern train derailed, and three cars from the Conrail train, two with multiple, stacked platforms, derailed. The Norfolk Southern conductor was killed; the engineer and student engineer sustained minor injuries. The two Conrail crewmembers were not injured.

The National Weather Service's closest official station to the accident, Fort Wayne, which is 28 miles southwest of Butler, reported the following conditions at the time of the accident: no precipitation, unrestricted visibility at 10 statute miles, a temperature of 36° F, and winds out of the northwest at 7 knots.

Preaccident Events—Conrail

The Conrail crewmembers, an engineer and a conductor, boarded their train at Elkhart, Indiana, on March 25, 1998, at 1:45 a.m. and departed Elkhart at approximately 2:30 a.m., after the locomotive units were fueled and the required air brake tests were performed.

The Conrail train, which was 2,101 feet long and consisted of 2 locomotive units and 14 intermodal cars,[4] was destined for Columbus. The crewmembers stated they were following an eastbound Conrail train and operating mainly on approach[5] signals, with an occasional clear[6] signal.

---

[1] Times given in this report are eastern standard time.

[2] See last page of this document for a list of all acronyms and abbreviations used in this report.

[3] Effective June 1, 1999, Norfolk Southern and CSX Corporation became Conrail's owners.

[4] A single car can consist of several connected, stacked platforms carrying intermodal shipping containers.

[5] Conrail and Norfolk Southern operating rules require that a train operating on an approach signal be prepared to stop at the next signal and begin reduction to medium speed as soon as the engine passes the approach signal.

[6] Indicates that a train may proceed at the authorized speed.

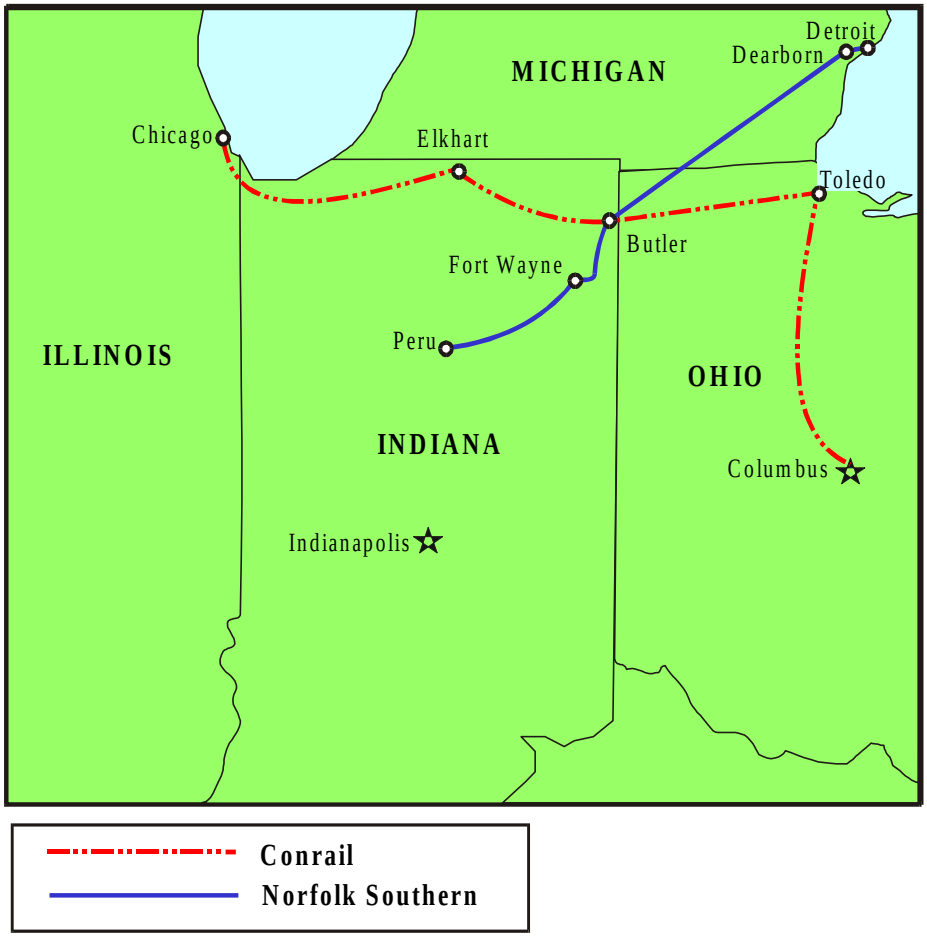


Figure 1. Conrail Chicago Line and Norfolk Southern Huntington and Detroit Districts

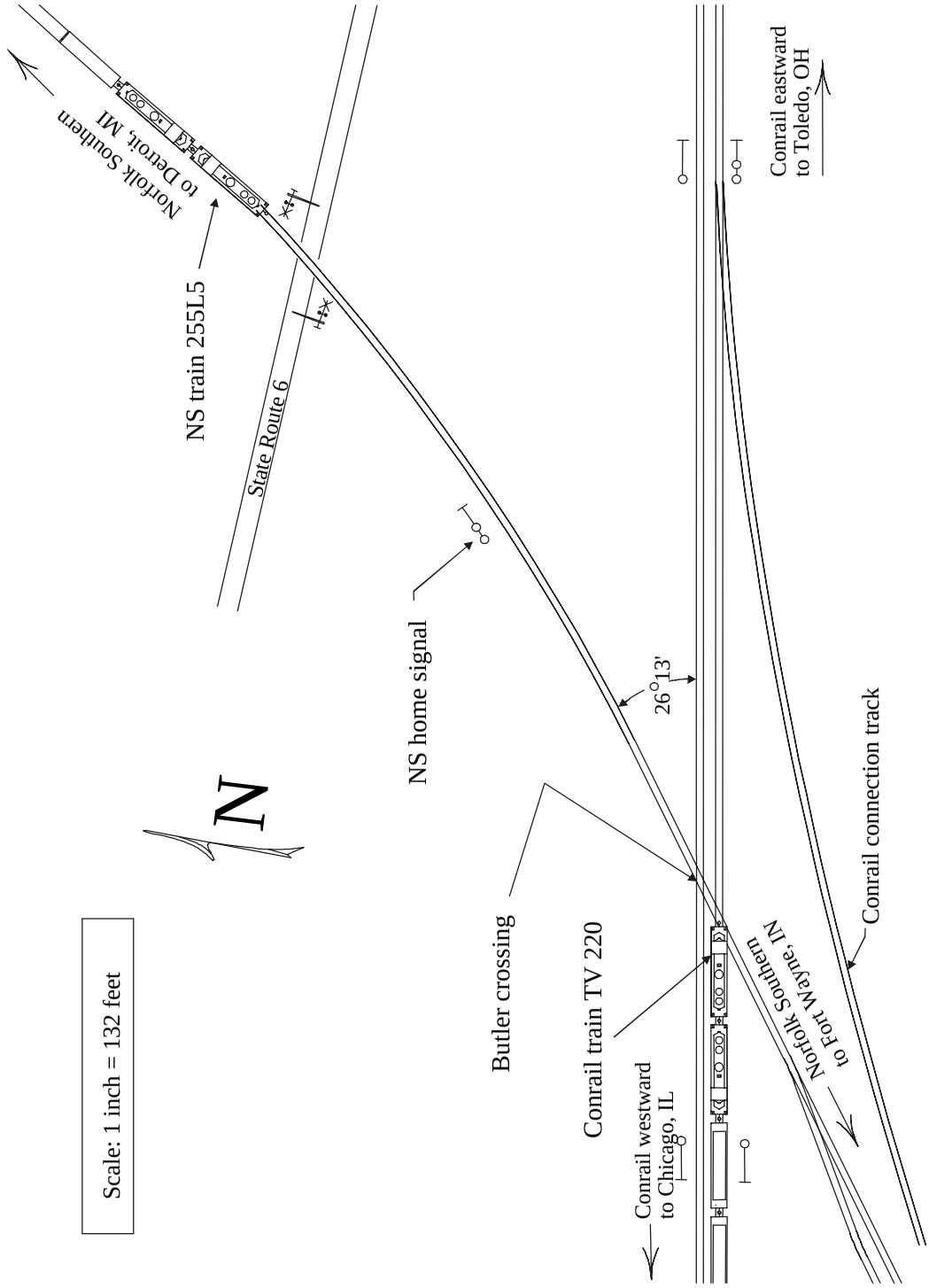


Figure 2. Southbound Norfolk Southern (NS) train approaching eastbound Conrail train at Butler crossing

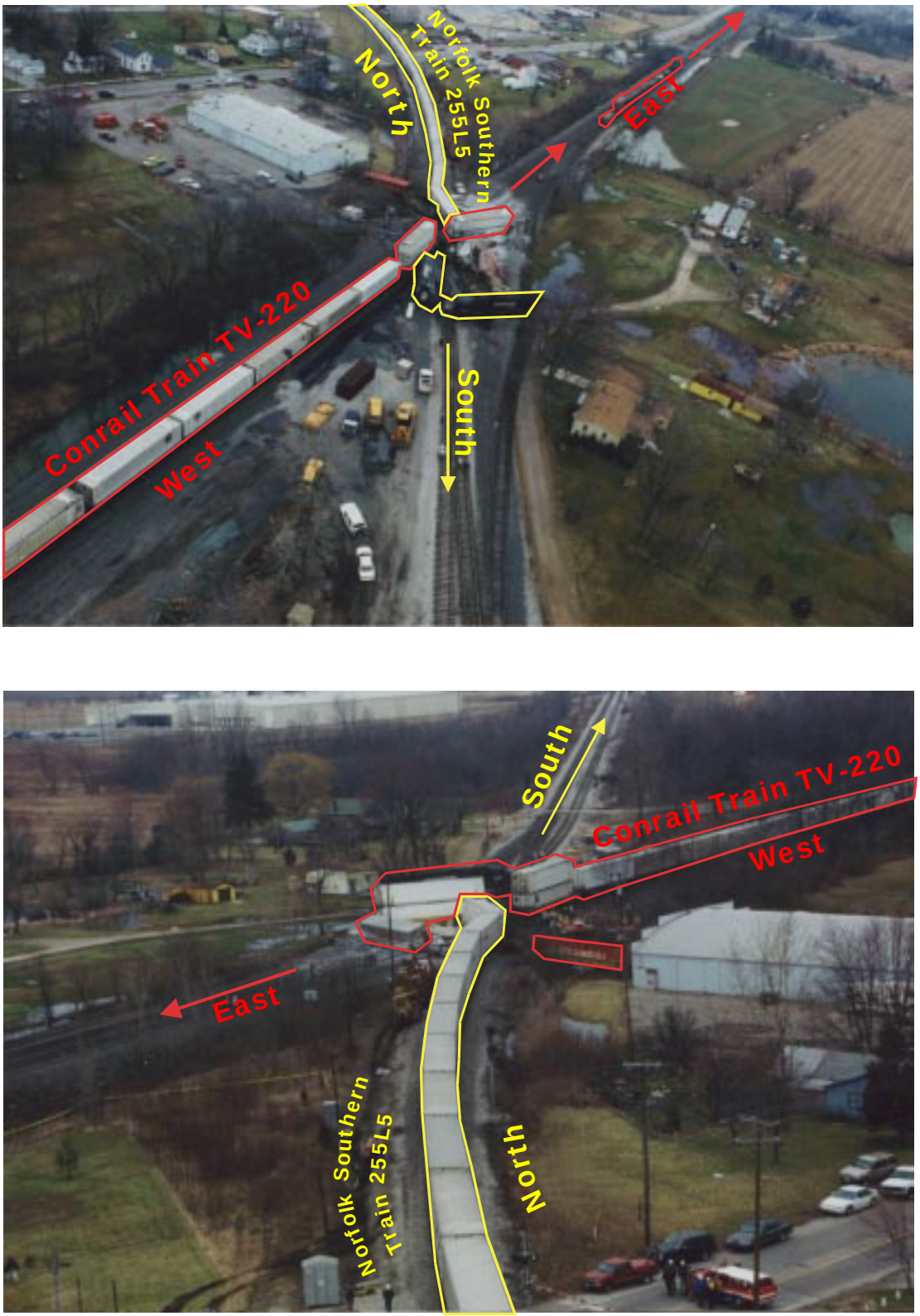


Figure 3. Conrail and Norfolk Southern (NS) trains viewed facing north *(top)* and south *(bottom)*

Several minutes before the collision, the Conrail intermediate signal[7] just before the Butler interlocking,[8] signal 360.2E, displayed an approach aspect, and the home signal[9] at the Butler interlocking was at stop. (See figure 4.) The crewmembers stated that they complied with the stop signal. After about 3 minutes, the signal upgraded to an approach aspect, and the train continued east.

While proceeding through the interlocking, both crewmembers stated that they observed an approaching headlight from the north, which they said was not unusual at that location. They could not determine the train's speed. Shortly afterward, the crew heard the Conrail train's air brakes apply in emergency.

Preaccident Events—Norfolk Southern

On March 24, 1998, at 11:35 p.m., the Norfolk Southern crewmembers, an engineer, a student engineer, and a conductor, reported for duty at the Detroit Terminal. After reading their orders and clearing them with the train dispatcher, the crewmembers boarded the two-unit locomotive consist at the round house and proceeded to their train in the Triple Crown facility. The train, consisting of 85 loaded road-railer[10] type cars, departed the facility about 2:30 a.m., after crewmembers had performed the required air brake tests.

Once the train left the terminal area, about 2:35 a.m., the engineer turned over the train's operation to the student engineer. At that point, the train was passing Oakwood Junction interlocking in east Dearborn, Michigan, about 114 miles northeast of Butler. The train continued southwest toward Fort Wayne. The student engineer reported nothing unusual about the train's handling before the accident.

The locomotive was being operated with the long hood forward,[11] with the student engineer seated at the controls on the right side of the lead locomotive; the conductor and engineer were seated on left side, with the engineer in the forward seat and the conductor directly behind him in the rear seat. Visibility to the left side of the locomotive is limited

---

[7] Signals between interlocking signals that convey the condition of the block ahead and provide the train crew with information needed to properly control train speed.

[8] An arrangement of signals and control apparatus so interconnected that functions must succeed each other in a predetermined sequence, thus permitting train movements along routes only if safe conditions exist.

[9] A fixed signal at the entrance of a route or block that governs trains or engines entering or using that route or block.

[10] Truck trailers equipped with wheels for rail operation.

[11] Modern diesel-electric locomotives have the controlling cab at one end of the locomotive superstructure. The remaining portion of the locomotive, which encloses the diesel engine and electrical generating plant, is referred to as the "long hood." Typically, locomotives are operated with the cab end or "short hood" leading for maximum visibility and generally have their controls on the right side. However, some railroads designate the long hood as the front end to provide added distance and material to protect the crew in a collision. A stenciled "F" designates the front end of a locomotive. The lead locomotive on Norfolk Southern train 255L5 was specially configured to have the long hood forward and the control stand on the right side.

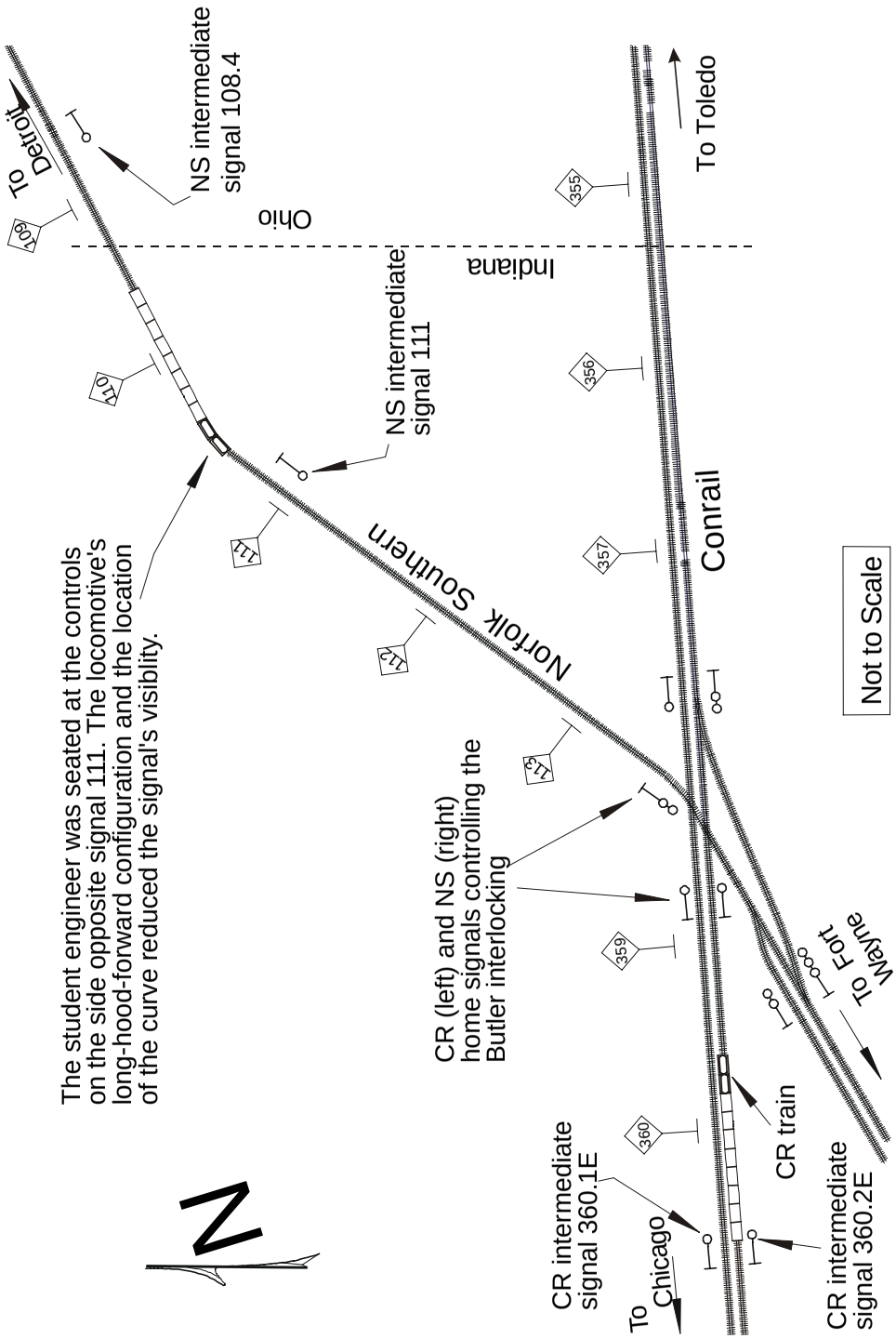


Figure 4. Conrail (CR) and Norfolk Southern (NS) signals in area of Butler interlocking

when it is being operated in this mode, as shown in figure 5. The student told Safety Board investigators that he had never been formally trained in long-hood-forward operation and had operated in this mode only once before, on a trip with the same crew from Peru, Indiana, to Detroit, Michigan, that concluded the day before the accident.

The student engineer said that the conductor and engineer did not call clear signals.[12] At the Norfolk Southern hearing,[13] the surviving crewmembers stated the conductor had told the student upon going on duty at Peru that it was the practice of the crew not to call clear signals. Norfolk Southern operating rule 34 requires that crewmembers "call," or orally communicate, all signals encountered.

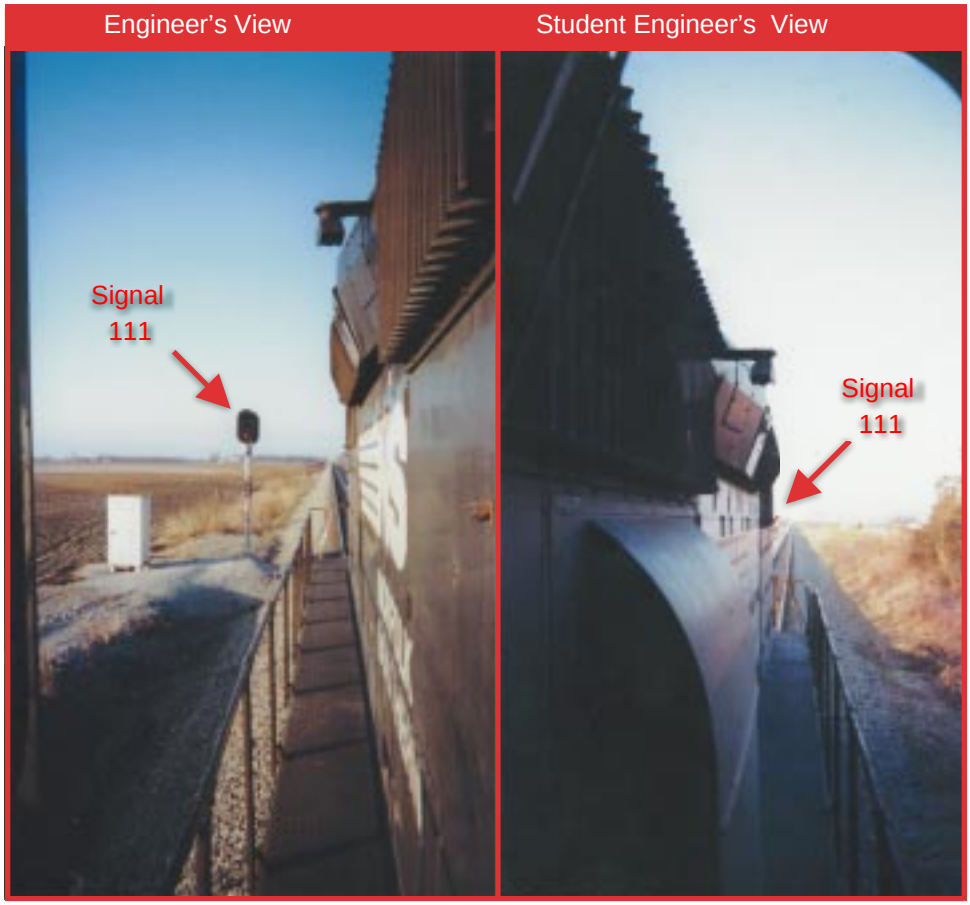


Figure 5. Signal 111 at last viewing point from left and right sides of cab on a locomotive configured with the long hood forward

[12] The student radioed every signal encountered on the accident trip up to signal 111. For a transcript of the tape-recorded communications, see docket CHI-98-FR-009.

[13] Norfolk Southern conducted its hearing on the Butler accident on October 7, 1998, in Fort Wayne.

In postaccident interviews with the Safety Board, the student engineer said that the engineer and conductor both started reading what he thought were paperback books shortly after 3:00 a.m., about 30 minutes after departing Detroit. Two paperback books[14] were found on the floor of the lead locomotive after the accident. (See figure 6.) The student engineer also said that about 30 minutes to an hour before the collision, the conductor or the engineer turned off the overhead light on the left side of the control compartment. The student said that he left the light on above his position to better observe the controls. The student was unsure how long the light was out on the other side of the cab, stating "It could have been a half hour, it could have been an hour. I don't know." He said that during the time the light was off, he did not talk to the engineer or the conductor or hear them talking to each other. He was unable to state with certainty whether the engineer or the conductor was asleep while the light was out, only that no communication occurred between crewmembers during that time.[15]

Figure 6. Books on floor of lead locomotive

In postaccident interviews with the Safety Board, the engineer admitted to reading, stating, "I had a paperback book that I was looking at back and forth." The engineer was unable to explain how or why he missed signal 111 but, while he was at the hospital undergoing treatment, told the Norfolk Southern division superintendent that he recalled

[14] *Chickenhawk* by Robert Mason and *Zen and the Art of Motorcycle Maintenance* by Robert M. Pirsig.

[15] The accident trip occurred at a time of day known for decreased alertness. For further information see: Rosekind, M., Gander, P., Connell, L., and Co, E., *Crew Factors in Flight Operations X: Alertness Management in Flight Operations.* NASA/FAA Technical Memorandum DOT/FAA/RD-93/18, 1994.

the conductor stating that the signal displayed an approach aspect. When asked by Safety Board investigators whether he was asleep before the accident, the engineer refused to answer on the grounds of self-incrimination. When questioned by Norfolk Southern officials about whether he or the conductor was asleep before the accident, the engineer responded, “Do I gotta say that?”

The student engineer said that as he approached Butler, intermediate signal 108.4 was displaying a clear indication, which he radioed over the road channel.[16] He did not see signal 111, the next intermediate signal on the left side[17] of the track and the last intermediate signal before the home signal at milepost (MP) 113.9, Butler interlocking.

Locomotive event recorder data indicated that the train was traveling approximately 60 mph (the maximum speed) as it passed signal 111. According to the student engineer, when it seemed the train had gone too far without encountering signal 111, he asked the conductor and engineer about the signal location. He said that he began slowing the train as the stop signal at Butler interlocking became visible and that “…Howard [the conductor] was coming across, and we saw it together; actually, and he said it [the home signal] was all red.” The student engineer said he was already in dynamic braking[18] and was applying more air brake when he heard the air brakes go into emergency. He said that he thought the engineer had applied the emergency brake using the valve on the left side of the cab. The student then placed the automatic brake valve handle in the emergency position.

The Accident

As the Norfolk Southern train approached Butler interlocking, the student engineer stated that he realized a collision was imminent when he saw the other train going across the crossing. He said he shouted, “We’ve got to get out of here” twice and turned to leave by the door behind his position. The conductor was the first to exit, followed by the student. The engineer stated that he saw both the conductor and student exit before he exited behind them.

The student stated that as he went down the locomotive stairwell and saw the proximity of the oncoming train, he jumped, landing in some water. The student could not recall whether the conductor jumped but did recall him being on the platform. The engineer stated the conductor was out of sight when he exited the cab and jumped from the locomotive.

---

[16] This is an open channel over which Norfolk Southern train crews orally communicate signals to radios tuned to that channel.

[17] Intermediate signals in the Norfolk Southern Huntington district are predominantly on the left side of the track for westbound trains.

[18] An electrical means of converting some of the energy of a moving locomotive into an effective retarding force.

Damage

About 4:48 a.m., the Norfolk Southern train, traveling at a recorded speed of 30 mph, struck the Conrail train. The lead Norfolk Southern locomotive derailed, remaining upright but facing east, while the trailing locomotive rolled over on its right side. Both Norfolk Southern locomotive cabs remained intact with only minor damage to the left side window of the lead unit, resulting in survivable space in both cabs. Both locomotive fuel tanks ruptured,[19] releasing about 7,000 gallons of fuel oil. The first through the fifth cars of the Norfolk Southern train derailed; the first four cars were completely destroyed. Norfolk Southern estimated total damages of $264,000 ($187,000 to equipment, $18,000 to track and signals, and $59,000 to cargo).

The Norfolk Southern locomotives passed completely through the sixth car of the Conrail train. Three of the cars from the Conrail train derailed, one of which was a five-unit articulated car. (See figure 7.) Conrail estimated total damages of $352,200 ($314,000 to equipment, $33,500 to track and signals, and $4,700 to cargo).

Figure 7. Point of impact

[19] These fuel tanks were conventional, frame-suspended tanks, a type that has been vulnerable to catastrophic puncture and fire in past derailments. The Safety Board will continue to monitor the Federal Railroad Administration's progress in improving locomotive fuel tank crashworthiness.

Postaccident Events

The Conrail engineer stated that after his train went into emergency, he immediately radioed "Emergency" three times over the road channel and contacted the train dispatcher in Dearborn. The Conrail conductor said that he then walked back to the interlocking, where he found the derailed equipment. The conductor said that a white powder covered the area and that he tried to avoid contact with the substance as he searched for injured persons.

The Butler fire department found the fatally injured Norfolk Southern conductor near the point of impact. The injuries sustained and the final resting point of the body suggested that the conductor was outside of the lead or trailing locomotive cab at the time of impact.

A Butler police officer who was in the vicinity of the accident responded immediately upon hearing the collision and notified DeKalb County dispatch. The officer encountered the student and the engineer from the Norfolk Southern train walking along the track. Both crewmembers were taken by ambulance to DeKalb Memorial Hospital for treatment of minor injuries. In addition, as directed by Norfolk Southern, they underwent drug testing in accordance with Federal Railroad Administration (FRA) regulations.

The Butler fire department responded within minutes and established a field command post, securing the scene and helping with search and rescue. Because the white powder spilled by the Norfolk Southern train was potentially hazardous, the DeKalb County Hazardous Materials Response Plan was initially activated for a level 3 response,[20] resulting in two schools being closed. When the two surviving Norfolk Southern crewmembers were unable to furnish the Butler fire department with a train consist listing the materials transported on the Norfolk Southern train, emergency responders donned self-contained breathing apparatus to collect information from one of the broken bags of white powder. The fire chief then attempted to contact the manufacturer. Because the accident occurred during nonbusiness hours, a cleaning person answered the telephone and provided the name of the only chemical manufactured by the company, nepheline syenite. (The cleaning person's information was later confirmed by company personnel during business hours.) The fire chief contacted CHEMTREC (Chemical Transportation Emergency Center), which confirmed that nepheline syenite is not a hazardous material. After about an hour, when the white powder had been identified as a nonhazardous material, the incident was downgraded to a level 2 response because of the diesel fuel on the ground. According to the Norfolk Southern Lake Division Supervisor, DeKalb County was not on the list of communities the company had coordinated with on emergency response planning.

[20] A level 3 response addresses a severe hazard or threat to life and the likelihood of a large-scale evacuation. The DeKalb County Hazardous Materials Response Plan automatically classifies any incident involving chemicals as level 1, a potential emergency condition, and classifies life-threatening incidents possibly requiring evacuation of the surrounding area as level 2.

Train Crew Information

Conrail Crewmembers

The Conrail dispatcher and crewmembers had undergone and passed the required physical examinations. The two Conrail 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 the night of March 25. Based upon the circumstances of the accident and the criteria contained in 49 *Code of Federal Regulations* (CFR) 219.201(c), Conrail exempted its dispatcher and crewmembers from postaccident toxicological testing.

Norfolk Southern Crewmembers

Engineer—The 45-year-old engineer was hired by Norfolk Southern as a switchman in January 1987 and, because of his previous experience as an engineer with another railroad, was promoted to locomotive engineer in July 1987. Disciplinary records show that the engineer was given a 15-day deferred suspension in July 1990 for failing to properly protect a movement. He received a letter of reprimand in November 1990 for failing to directly supervise a student engineer (he had left the locomotive cab while a student engineer was at the controls) and a 30-day suspension in July 1991 for operating a train over the maximum permissible speed. This engineer was assigned a student during the Peru and Butler trips because the student engineer's regularly assigned engineer was on leave.

The engineer had attended operating and safety rules classes within the past year. In August 1997, he passed the physical examination required by the railroad every 3 years for recertification as an engineer. Company records indicate that he was in compliance with the Hours of Service Act and had been off duty for approximately 16 hours before reporting to work the night of the accident. In postaccident interviews, the engineer said that he had slept for approximately 8 hours during this time (4 to 5 hours of sleep and a 3.5-hour nap). Postaccident toxicological tests conducted in accordance with FRA regulations were negative for the presence of alcohol and specified drugs.[21]

Student Engineer—The 38-year-old student engineer was originally hired by Norfolk Southern as a trainman in January 1995. He was promoted to conductor in August 1995. In February 1998, he successfully passed the classroom phase of locomotive engineer training.

Disciplinary records show that the student engineer was given a 10-day deferred suspension in April 1996 in connection with damage to a locomotive. In August 1997, he received a letter of reprimand for failure to properly protect an assignment.[22]

---

[21] Marijuana, cocaine, opiates, amphetamines, and phencyclidines (PCPs) in accordance with 49 CFR Part 219, Subpart C.

[22] Leaving an assignment early without permission or failing to report or reporting late to an assignment.

Company records indicate that he had attended operating and safety rules classes within the past year and had passed the railroad's required physical examination in January 1998. He was in compliance with the Hours of Service Act and had been off duty for approximately 16 hours before reporting to work the night of the accident. In postaccident interviews, the student engineer said that he had slept for approximately 8 hours during this time (7 hours of sleep combined and a 1-hour nap). Postaccident toxicological tests conducted in accordance with FRA regulations were negative for the presence of alcohol and specified drugs.

Conductor—The 59-year-old conductor was first employed by Norfolk Southern in June 1963 as a fireman and was promoted to conductor in July 1968.

Norfolk and Western Railway Company (N&W) disciplinary records reveal that the conductor was dismissed from service in March 1974 for violating rule G, which concerns the use and possession of alcoholic beverages. He was reinstated in March 1975. He received a 20-day deferred suspension in September 1988 for an air brake testing violation.[23] He was dismissed from the N&W in September 1988 for conduct unbecoming an employee and was reinstated in December 1989. In August 1993, he received a 10-day deferred suspension for not responding to a call for a conductor. In October 1993, he received a 30-day deferred suspension for missing a call, which activated the 10 days that had been deferred in August 1993. In March 1996, he received a 10-day deferred suspension for failing to properly secure cars left standing on a main track. On March 26, 1997, the conductor was issued a letter of reprimand for violating operating rule 34, the communicating of signals. In January 1998, he was cited for improperly performing his duties and exposing himself to possible injury when he mounted a moving car. Records did not indicate whether he was assessed a penalty for that action.

Company records indicate that the Norfolk Southern conductor had attended operating and safety rules classes within the past year. The conductor's most recent physical examination, in November 1997, was conducted for "return to work" purposes because he had been off work due to a cardiac condition. Medical records indicate that he was taking aspirin and the following brand name prescription medications: Cardizem CD, Dyazide, Tenormin, and Zocor.[24] The conductor was in compliance with the Hours of Service Act and had been off duty for approximately 16 hours before reporting to work the night of the accident. No information was available on the conductor's rest during this period. Kidney, brain, and liver specimens obtained from the deceased conductor and tested in accordance with FRA regulations were negative for the presence of alcohol and specified drugs.

Dispatcher—The 36-year-old train dispatcher was first employed by Norfolk Southern in November 1985 as a clerk and was promoted to dispatcher in October 1996.

[23] N&W disciplinary records do not specify whether the conductor performed the test improperly or not at all.

[24] Cardizem CD and Tenormin are commonly used to treat angina, irregular heartbeat, and high blood pressure. Dyazide is commonly used to reduce fluid retention and control high blood pressure. Zocor is commonly used to lower blood cholesterol.

Disciplinary records disclosed no actions pertaining to the dispatcher. Based on the circumstances of the accident and on 49 CFR 219.201(c), Norfolk Southern exempted the dispatcher from postaccident toxicological testing.

Track and Site Information

Butler, a rural town with a population of 2,800, is in the northeast corner of Indiana, approximately 3½ miles from the Ohio State line. The Norfolk Southern Huntington District and the Conrail Chicago main lines cross at grade on the east side of the town. The Conrail tracks pass through Butler from east to west, while the Norfolk Southern track runs from northeast to southwest. (See figure 2.) The railroad crossing at Butler was initially installed in 1881 by predecessor railroads of both carriers.

Conrail refers to the crossing as "CP [control point] 358," and locates it at MP 358.5 on its timetable. Norfolk Southern refers to the crossing as "Butler," and locates it at MP 113.9 on its timetable. The Butler interlocking consists of two track crossings, or diamonds, at the points where the single-track Norfolk Southern main line crosses the Nos. 1 and 2 main lines of the double-track Conrail Chicago Line. (See figure 2.)

The Huntington District of the Norfolk Southern Lake Division is a predominantly single-track main line with sections of double track and numerous controlled passing tracks. The Huntington District, in combination with the Detroit District, forms the Norfolk Southern route between Detroit, Michigan, and Peru, Indiana. This route handles approximately 20 trains per day and is used for the movement of automobile parts, finished automobiles, chemicals, and merchandise. Grades are moderate, and trains normally operate at a timetable speed of 60 mph. The speed limit is 60 miles per hour, with several areas of speed restrictions for curves. Due to curvature and the diamond, Butler has a permanent speed restriction of 50 miles per hour for all trains. At the exact location of the diamond, the grade is 0.21 percent ascending for a westbound train.

The Chicago Line supports over 110 million gross tons annually and is the busiest segment of the Conrail Dearborn Division. The corridor handles virtually every type of rail traffic, including six daily Amtrak (National Railroad Passenger Corporation) trains. East of Butler, approaching the crossing, the track is tangent (straight) for 68 miles. Tangent track extends west of the diamond for about 0.3 miles. At the diamond, the track is nearly level, with a recorded grade of 0.08 percent, descending to the east. Both tracks have a timetable speed of 60 miles per hour for freight trains and 79 miles per hour for passenger trains.

On the day of the accident, timetable speeds were in effect for both carriers, with no temporary speed restrictions. Both Conrail and Norfolk Southern inspected their track and diamonds 2 days before the accident (March 23) and noted no defects. In addition, crewmembers did not mention track concerns to Safety Board investigators.

Norfolk Southern Operating Rules

Norfolk Southern general regulation GR-3 states, "All employees must follow instructions from proper authority, and must perform all duties efficiently and safely." The Norfolk Southern operating rules, effective July 2, 1995, and the Norfolk Southern Lake Division Timetable No. 3 instructions govern trains operating on the Lake Division.

The operating rules define overall areas of responsibility for both conductors and engineers. Rule 581 states:

> Conductors have charge of the trains to which they are assigned and all employees thereon. They are responsible for safe and proper management of their trains, for protection and care of passengers and property, for performance of duty by train employees, and for observance and enforcement of all rules and instructions.

Rule 601 states:

> Engineers are responsible for the proper performance and handling of engines, for care of equipment and economical use of fuel and supplies…."

In addition, the operating rules specifically define responsibilities for all train crewmembers pertaining to signal indications and signal calling. With regard to signal indications, Norfolk Southern operating rule 240 requires that trains encountering a stop signal come to a stop. Rule 285 requires that trains encountering a signal displaying an approach aspect do the following: "Proceed preparing to stop at next signal. Train or engine exceeding Medium Speed [not exceeding 30 mph] must at once reduce to that speed."

Rule 27 states, in part, that trains approaching a dark signal should regard that signal as the most restrictive indication possible and promptly report the condition:

> A signal imperfectly displayed, a signal functioning erratically, the absence of a light, a white light displayed where a colored light should be, or in the absence of a signal at a place where a signal is usually shown, must be regarded as the most restrictive indication that can be given by that signal and must be promptly reported to the train dispatcher, control station, or yard master.

Norfolk Southern further discusses crewmember responsibilities for observing and reporting improper signal indications in rule 244:

> Should an improper signal indication permitting a train to proceed be observed, employees must report the fact to the proper authority by the quickest means of communication. In addition, all employees must take such action as possible to provide protection for the movement of trains

> and engines. Crew members who are in a position to do so must observe whether signals passed by their train or engine assume proper indication.

Operating rule 34 requires that crewmembers "call," or orally communicate, all signals encountered but does not require that crewmembers permanently record them. The rule further states:

> The engineer must comply with the indication of each block, interlocking and other signal that affects the movement.
>
> Crew members located in the operating compartment must occupy a window seat when available, and must maintain a vigilant lookout for signals and conditions along the track that affect the movement. Crew members located in the operating compartment who cannot avail themselves of a window seat must maintain a vigilant lookout for signals and conditions along the track within their view, that affect the movement.
>
> Employees located in the operating compartment of an engine must communicate to each other in an audible and clear manner by its name the indication of each signal affecting movement of their train or engine as soon as the signal is clearly visible or audible. Each signal must be called (1) as soon as it is clearly visible or audible and (2) again, if other than a stop signal, just before the signal is passed. It is the responsibility of the engineer to have each employee comply with these requirements.
>
> When crew members ride in the trailing units their first duty is to observe signals affecting the movement. If other crew members are present, they must communicate to each other by its name the indication of each signal.
>
> A crew member on the controlling locomotive will communicate by radio the name and location of each signal affecting his movement as soon as the signal becomes visible.
>
> If there are crew members on trailing units and/or caboose they will acknowledge the transmission, repeating the information to crew member(s) on the controlling locomotive.
>
> Example of correct procedure to initiate the radio transmission when all crew members are on the controlling unit:
>
> "NS Train 187 has an Approach signal on No. 1 main at MP 179.3 for Cumberland Falls, out."
>
> Examples of correct procedures to initiate and acknowledge the radio transmission when there are crew members on trailing units and/or caboose:
>
> "Engineer Scott, NS train 194 has a Diverging Approach signal at the north end of Philpott, over."

> "Brakeman Hodges, NS train 194, acknowledging the Diverging Approach signal at the north end of Philpott, out."
>
> If the engineer fails to control movement in accordance with signals or other conditions, crew members must communicate with him at once. If he then fails to immediately control the speed properly they must take necessary action to stop the train.

Title 49 CFR 217.9 requires that each railroad conduct operational tests to determine the extent of compliance with the operating rules. Norfolk Southern Lake Division testing records indicate that the following occurred from March 1997 through February 1998:

Tests	Observations*	Total	Failures	Failure rate
385,987	243,279	629,266	4,378	0.70%

* Generally recorded by Norfolk Southern supervisors during the course of normal operations, as opposed to during a period specifically designated for rules testing.

Of these tests, 17,278 were conducted specifically on rule 34 compliance, resulting in 283 reported failures, or a 1.64-percent failure rate. Records also indicate that the Norfolk Southern engineer was tested 11 times for Norfolk Southern operating rule 34 compliance from January 1, 1997, to March 25, 1998, with no reported failures. In addition, the Norfolk Southern conductor was tested 15 times for Norfolk Southern operating rule 34 compliance for the same period. On March 26, 1997, at Butler, the conductor was found in violation of rule 34 and issued a letter of reprimand. According to the surviving crewmembers, the conductor had instructed the student engineer that it was the practice of the crew not to call clear signals. According to Norfolk Southern officials, this instruction was in violation of Norfolk Southern operating rule 34.

Postaccident Tests

Visibility and Sight Distance

To replicate the conditions on the day of the collision, investigators conducted sight distance tests in the predawn hours of March 26, the day after the accident. Engine 6507, a unit identical to engine 6508 (the lead Norfolk Southern locomotive in the collision), was used for the tests. The locomotive traveled in the same direction and at the speed recorded by the accident train's event recorder (60 mph). In addition, the locomotive was configured identically to engine 6508 (long hood forward and the control stand on the right side).[25] Sight distances were taken from both the left and right sides of the locomotive cab.

[25] Some railroads designate the long hood as the front end to provide added distance and material to protect the crew in a collision. The lead locomotive on Norfolk Southern train 255L5 was specially configured to have the long hood forward and the control stand on the right side.

The tests showed that a crewmember at the control stand (right side), where the student engineer was seated, could see intermediate signal 111 from a distance of 1,397 feet. The signal would no longer be visible from the control stand at 678 feet because visibility is limited by the long hood of the locomotive (see figure 5).[26] The Safety Board further determined that a crewmember seated at the control stand could see signal 111 for 719 feet, which at 60 mph translates to approximately 8 seconds. From the left side of the cab, where the conductor and engineer were seated, this signal was visible for 1,698 feet. A crewmember positioned on the left side of the cab could therefore see the signal for approximately 19 seconds before advancing past it.

The sight distance from the right side of the locomotive for the home signal at Butler interlocking was 5,232 feet, meaning at 60 mph, the signal could be viewed from the control stand for approximately 60 seconds. From the left side of the cab, the signal was visible at 5,254 feet, or for approximately 60 seconds.

Signals

Conrail trains receive authorization to move from the signal indications of a traffic control signal (TCS) system controlled by the Toledo West train dispatcher in Dearborn. Norfolk Southern trains receive authorization to move from the signal indications of a TCS system controlled by the Norfolk Southern Huntington train dispatcher in Fort Wayne. Both Conrail and Norfolk Southern train movements through the Butler railroad crossing at grade are authorized by the signal indications of an interlocking signal system controlled by the Conrail Toledo West train dispatcher in Dearborn. The TCS and interlocking signal systems are interconnected and operate seamlessly.

Conrail—A postaccident signal examination indicated that the TCS system signals were displaying the proper signal sequence for Conrail train movements on both tracks. The signal inspection records and the signal event logs did not indicate deficiencies that would have prevented the TCS system from operating properly. The Conrail crewmembers stated they had a good view of the home signal at the Butler interlocking and reported that the weather at the time of the accident was clear, with no visibility problems.

The signal event logs from the equipment at Conrail CP 358 (Butler crossing) and the diagnostic log from the Computer Aided Train Dispatching Facility in Dearborn indicated that the dispatcher was lining signals for Conrail train movements while home signal 113.9, governing the movement of Norfolk Southern southbound trains through the Butler crossing, displayed a correct stop aspect. The signal event logs recorded the aspect of signal 113.9 as unchanged for approximately 2 hours before the accident. The logs also recorded a Conrail train occupying the interlocking track circuit past signal 113.9 just before the collision.

[26] Norfolk Southern has 1,190 of its 2,242 locomotives configured with the control stand on the right side when operating with the long hood forward.

Norfolk Southern—Postaccident signal testing was conducted to determine the aspects for the intermediate signals preceding Norfolk Southern home signal 113.9 as the Norfolk Southern train approached the Butler crossing. (See figure 4.) The tests, which included signals 108.4 and 111, found that the proper codes were being transmitted to signal 111 from the electronic track circuit unit at Butler interlocking (Conrail CP 358). When tested, the signal system transmitted codes in a logical progression and displayed signal aspects that were not in conflict with each other. Further, tests indicated that the proper codes were being transmitted to signal 108.4 from the electronic track circuit unit at signal 111 under all conditions. When signal 111 displayed a yellow, or approach, aspect, signal 108.4 displayed a green, or proceed, aspect. When signal 111 was dark, signal 108.4 downgraded to a yellow, approach, aspect. Crew interviews and recorded radio conversations between the student and dispatcher indicated that signal 108.4 displayed a green, proceed, aspect when the Norfolk Southern train went past it on the day of the accident.

Signal 111 was observed going dark at random intervals during the postaccident investigation; consequently, the Electro Code 4 unit containing the lighting module was removed and bench tested. Bench tests identified failed internal aluminum electrolytic capacitors[27] that caused the signal to go dark for 10 to 24 seconds. (See figure 8.) This failure did not cause the signal to show any other inappropriate aspect, such as a less restrictive signal aspect. Norfolk Southern operating rules require that engineers treat a dark signal as the most restrictive aspect possible for that signal, which in the case of signal 111 is a restricted signal, meaning that the train could proceed at a restricted speed.

The investigation further revealed that the signal data recorder[28] at MP 111 was affected by the failed capacitors. The device recorded events despite no physical changes occurring in the operational status of the signal location, thus rapidly filling the memory buffer and overwriting older recorded events, including events that occurred at the time of the accident.

Field inspections of other Harmon Electro-Code 4 units in the Lake Division found evidence of capacitor failures on the 212A modules manufactured from 1987 to 1988. On May 15, 1998, Harmon Industries issued product improvement announcement PIA 98-101 detailing the failure of the capacitor and explaining how to exchange the 212A module for a replacement. (See appendix A.) By the time Harmon issued this announcement as a result of the failures at signal 111, the faulty unit at signal 111 had been replaced. The company also offered components and modification instructions to railroads preferring to and capable of making their own modifications.

Harmon Industries provided field technicians to aid Norfolk Southern in a systemwide program to identify and replace all modules manufactured from 1987 to 1988.

[27] Electronic device capable of storing an electric charge by means of two electrodes separated by electrolytic fluid (wet capacitor). Loss of the electrolytic fluid renders the device open and ineffective in circuit operations.

[28] Records track codes, signal aspects, signal-light-out conditions, track occupancy, and other critical functions.

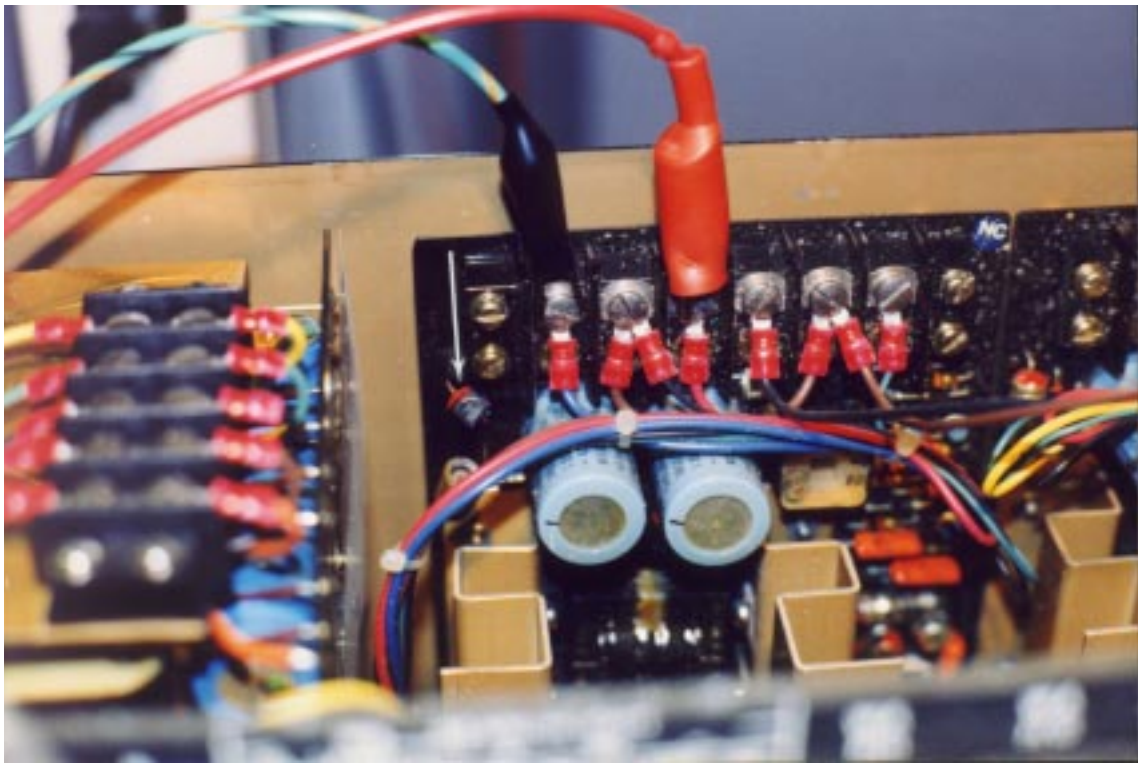


Figure 8. Failed capacitor *(at arrow)* from MP 111 Electro Code unit

During Safety Board depositions held in October 1998, Norfolk Southern Signal Department officials stated this program was complete for all Norfolk Southern divisions.

Norfolk Southern Signal Malfunction Reporting

The investigation revealed that the failed capacitors were on an electronic unit not accessed during required maintenance tests and inspections. Thus, a signal maintainer would either have to observe the signal failure or receive a report of one to be aware of a problem.

Norfolk Southern train crews reporting a malfunctioning signal must report the event to the dispatcher. The dispatcher then completes a signal report form and notifies the signal maintainer responsible for the territory where the report occurred, who subsequently investigates the malfunction. After repairing the malfunction or determining its cause, the maintainer notifies the dispatcher of the result of the investigation. The dispatcher logs the maintainer's report on the form, records any train delays caused by the signal failure, and files a copy of the form.

A copy of all signal report forms completed by dispatchers is provided daily to the reporting division's chief dispatcher and Signal General Supervisor. These individuals review the reports to determine whether further followup is required or to coordinate train movements if the problem will cause further delays. The General Supervisor also reviews

the reports with division supervisors to determine the final outcome of reported malfunctions.

Signal malfunction reports indicated that signal 111 had been reported on two different occasions as downgrading from a yellow, approach, aspect to a dark aspect as trains approached it. Following the first reported dark signal on February 19, 1998, the Norfolk Southern signal maintainer responsible for the territory responded to the call and reported that signal 111 was working properly. Because the cause for the malfunction could not be determined, the signal maintainer installed a signal event recorder card so that the signal log could be downloaded later and checked for abnormalities in the signal's operation. However, Norfolk Southern personnel did not download the log.

After signal 111 was again reported going dark in March, the Lake Division Signal General Supervisor requested a download from the division supervisor. The Lake Division Signal General Supervisor said that he was unaware of the previous dark signal report. On March 22, 1998, 3 days before the accident, while responding to the second report of signal 111 going dark, the Norfolk Southern signal maintainer who had responded to the February call observed a train operating past the reported signal. He again reported the signal to be working properly. The signal maintainer stated that he was dispatched to attend to a malfunction at a different location before he could test or download the signal event recorder log. The download occurred following the accident.

Locomotive Engineer Training Program

After meeting eligibility requirements, candidate student engineers must attend training in McDonough, Georgia, for 1 month before returning to their divisions for on-the-job training. The training at McDonough, Georgia, consists of classroom training and 20 hours of training in a locomotive simulator. According to Norfolk Southern Training Center personnel, none of the school's locomotive simulators are configured in the manner of the accident train, with the long hood forward, but students may have the opportunity to operate a train in that configuration on the school's training track during their month in McDonough. Training Center personnel also stated that the school considers training student engineers for conditions that may be unique to a division, such as long-hood-forward operation, to be the division's responsibility. The section governing student engineer training in the company's locomotive engineer certification program[29] submitted to the FRA on June 13, 1995, does not cite knowledge of or practice in long-hood-forward operation as training objectives.

The student engineer completed the classroom phase of the locomotive engineer training program in McDonough in early February 1998 and had successfully completed all training requirements and tests by the end of the month. The student engineer then followed the typical route of Norfolk Southern student engineers in reporting back to his

[29] Section 5, "Training, Testing, and Evaluating Persons Not Previously Certified," from Norfolk Southern's 49 CFR Part 240 submission *Certification of Locomotive Engineers* (October 1991, revised June 1995).

division for on-the-job training. This training focuses on gaining experience in operating a locomotive and on qualifying on the physical characteristics of the territory,[30] that is, becoming familiar with the physical characteristics of the track over which the trainee will eventually operate. In this case, the student engineer was not assigned to the territory in which he had worked as a conductor.

According to the Norfolk Southern Division Road Foreman of Engines (DRFE), student engineers, upon returning to their divisions for on-the-job training, meet with a road foreman. The road foreman instructs the student engineer on what is expected of trainees during the on-the-job phase of training, to include presenting the student engineer with a list of operating requirements. (See appendix B.) The DRFE said that the student engineer then either chooses, or is assigned, a coach engineer.

The investigation revealed that on March 3, 1998, the student signed a form listing the operating requirements for student engineers, including the stipulation that he can operate trains only with his regularly assigned engineer or with another coach-trained engineer who has been working for at least 1 year.[31] The train 255L5 engineer was not the student's regular engineer and was not coach trained. (See appendix B for the student's copy of the form.) According to the DRFE, for a student engineer to operate a train:

- The student engineer must determine that the engineer is coach trained.
- The coach-trained engineer must confirm that the crewmember is a student engineer and is knowledgeable of the applicable rules and regulations.

The student stated after the accident that he was aware that engineers must have at least 1 year of operating experience but that he had forgotten or did not realize they are also supposed to be coach trained.

The DRFE said that Norfolk Southern had compiled a list of coach-trained engineers, although he was unable to confirm whether that list had been published before the accident. The student engineer stated that he received this list several months after the accident. The DRFE also stated that it is up to the student to inform the engineer that he can operate the train only with a coach-trained engineer and that Norfolk Southern does

---

[30] Locomotive engineers qualify on the physical characteristics of a territory by making several trips to become familiar with track grades and curvature, signal locations, interaction with the train dispatcher, and other operational factors unique to a particular area. Student engineers who have previously worked in a territory as a conductor and are therefore somewhat familiar with the territory must still learn the territory's grades and train control requirements. The road foreman determines when a student engineer has qualified on the physical characteristics of a particular territory.

[31] Regularly assigned engineers are always coach trained. Coach-trained engineers are selected to supervise on-the-job training of student engineers based upon their ability to effectively communicate with and be a mentor to others. A candidate coach engineer must have been an operating engineer for at least 1 year and have viewed the company's coach training video and read the accompanying participant's guide. The DRFE testified to Safety Board investigators in November 1998 that the Lake Division had between 50 and 60 student engineers and 400 coach-trained engineers participating in its locomotive engineer training program.

not provide information on the student engineer program to engineers who are not coach trained. The engineer of train 255L5 was not coach trained.

Student engineer evaluations are completed on a monthly basis by a district road foreman (DRF). Because the student engineer had been assigned to the Lake Division for less than 1 month at the time of the accident, he had not yet been observed and evaluated by a DRF. He was uncertain about the feedback process related to his performance and added that he had never received written feedback from a Norfolk Southern employee or been observed by a road foreman.

The engineer stated that when students accompanied him during trips, he did not complete written evaluations of their performance and was not required to because he was not a coach-trained engineer. He also indicated that Norfolk Southern did not provide him with training on how to evaluate student engineers. He believed that training provided by Norfolk Southern on instructing student engineers was inadequate and that there was "complete confusion with [the] engineer process from the beginning."

Crew Communication

The engineer and the student engineer both stated that they had previously known or worked with each other until almost 2 days before the accident, during the trip from Peru to Detroit that began late March 23. The student also said that he had operated a locomotive once or twice in other areas and had been on trains traveling through the accident area about six times before the Peru trip. During the company's October 7, 1998, hearing, the engineer testified that the student engineer and conductor "had been working together" and that the student engineer was "more his boy than mine." The engineer added that the conductor "convinced me to let him [the student engineer] run the engine in the first place."

The engineer stated that he preferred not to have student engineers with him while operating trains and that he was unaware that a student would be with him until the student engineer arrived late March 23 for the trip from Peru to Detroit. The engineer stated that he quizzed the student engineer during that trip and was impressed with his knowledge of signal locations, speed restrictions, and interlockings. He indicated that he and the student engineer also discussed the student's ability to operate a locomotive. The engineer said that he allowed the student engineer to operate the train during the accident trip because of the conductor's opinion of the student's abilities and his own observation of the student's performance during the previous trip from Peru to Detroit.

Analysis

This analysis consists of three general 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. The balance of the analysis discusses the major safety issues identified in this investigation:

- Adequacy of Norfolk Southern's methods for ensuring compliance with the operating rules,
- Adequacy of Norfolk Southern's locomotive engineer training program, and
- Importance of train crew resource management to safe and efficient train operations.

The analysis also addresses additional safety concerns identified during the investigation: the adequacy of Norfolk Southern's signal malfunction reporting procedures and of Harmon Industries' signal component repair and replacement program, the continued need for in-cab audible recording devices on trains to provide essential details for accident investigations, and the importance of emergency response management in railroad accidents involving hazardous materials.

Exclusions

Both train crews had satisfactorily performed the required pretrip tests of their trains and reported no deficiencies. In addition, postaccident testing revealed no track defects in the accident area, and crewmembers did not mention track condition as a concern. Therefore, the Safety Board concludes that the mechanical condition of the trains and track did not contribute to this accident.

The National Weather Service in Fort Wayne, Indiana, reported unrestricted visibility at 10 statute miles and no precipitation at the time of the accident. Therefore, the Safety Board concludes that neither weather nor visibility had a role in this accident.

A postaccident signal evaluation revealed that the Conrail traffic control system displayed the proper aspect sequences for Conrail train movements. In addition, the interlocking signal system did not display conflicting signals; the Norfolk Southern home signal was at stop in response to the Conrail train's proceeding through the crossing on an approach signal. Therefore, the Safety Board concludes that the operation of the Conrail signal system and the interlocking signal system did not contribute to this accident.

The carriers determined that the Conrail train crewmembers and the Conrail and Norfolk Southern dispatchers did not contribute to the accident and thus exempted them from toxicological testing. Postaccident testing for alcohol and specified drugs conducted on the Norfolk Southern crewmembers was negative. Members of both train crews had taken the required operating and safety rules classes in the past year. In addition, the

Norfolk Southern student engineer had successfully completed all training requirements and tests for the classroom phase of the locomotive engineer training almost a month before the accident. Consequently, the Safety Board concludes that neither alcohol and drug use nor train crew qualifications were factors in this accident.

Accident Discussion

The Safety Board's analysis of the signal event logs from the equipment at the Butler interlocking and of the diagnostic log from the Computer Aided Train Dispatching Facility in Dearborn indicates that home signal 113.9, governing Norfolk Southern southbound trains, had correctly displayed a stop aspect at the time of the accident. This was also confirmed by the crew's testimony. Signal event logs recorded the aspect of home signal 113.9 as unchanged for approximately 2 hours before the accident and also recorded a Conrail train occupying the interlocking track circuit past signal 113.9 just before the collision. Furthermore, sight distance tests performed the day after the accident demonstrate that Norfolk Southern's crewmembers could have seen signals 111 and 113.9.

The student engineer radioed to the dispatcher every signal that he encountered up to signal 111, including the clear indication at the immediately preceding signal, 108.4, indicating that he was attentive and vigilant during the accident trip. In addition, the engineer had been impressed with the student's knowledge of signal locations based on a conversation with the student during the Peru trip. However, the student engineer told investigators that he missed signal 111. Several factors could explain the oversight. First, the student was not yet qualified on the physical characteristics of the territory. In fact, the territory to which he was assigned was not the same territory in which he had worked as a conductor, thus limiting his familiarity with it to the six trips he had made through the area before working with the Butler train crew. In addition, he had never operated a locomotive in the accident area before the Peru and Butler trips. Further, although investigators could not determine whether the intermittent dark signal discovered during the postaccident investigation at MP 111 was dark when the Norfolk Southern train passed it (see "signal malfunction reporting" later in analysis), had the signal been dark, it may have contributed to the student engineer's confusion about the train's location. Finally, the operation of the train with the lead locomotive in the long-hood-forward configuration limited the student engineer's visibility from the left side of the locomotive, where MP 111 was located. The Safety Board concludes that the reduced visibility on the student's side of the cab as the train approached MP 111, compounded by a possible dark signal and by the student engineer's lack of experience, may have caused the student to miss the signal and the reflectorized milepost marker. None of these factors, however, applied to the engineer and conductor. Had the conductor and engineer called the clear signal at MP 108.4 in compliance with Norfolk Southern operating rule 34, their attention would have been engaged before the accident. Calling the signal, in turn, would have set the stage for the train either to prepare to stop in response to an approach signal in accordance with rule 285 or to stop in response to a dark signal in accordance with rule 27, which requires that a dark signal be treated as the most restrictive indication possible. The Safety Board concludes that because of the engineer's and conductor's lack of vigilance and decision

not to call clear signals, the crew of Norfolk Southern train 255L5 failed to react to either an approach or a possible dark signal at MP 111.

This collision is yet another accident that could have been prevented had a positive train separation (PTS) system been in place and operational. PTS systems monitor and control train operations, slowing or stopping trains when the braking distance between trains is insufficient for safety.

PTS can be implemented through on-board computers with communication links to a control center. The trains' on-board computer systems are automatically and continuously updated with information including speed limits, work in progress on the right-of-way, the location of the preceding and following trains, track integrity, and train makeup conditions (length and weight of trains). If necessary, a PTS system can apply train brakes automatically to keep trains apart, enforce speed restrictions and signal indications, or stop trains short of an improperly lined switch or other known obstruction. Depending upon the railroad's current signal and train control system, PTS systems can be used to provide various levels of operation, enhancing a railroad's current signal and train control system or providing protection to trains on railroads without signal and control systems.

When the student engineer failed to slow his train for signal 111, a PTS system would have intervened by applying the train brakes and stopping the train short of the Butler interlocking. The Safety Board concludes that a fully implemented PTS system would have prevented this accident. The Safety Board strongly advocates the development of PTS systems for U.S. railroads and has included PTS on its list of "Most Wanted Transportation Safety Improvements."

Although the investigation revealed no evidence of fatigue on the part of any crewmember involved in the accident, statements made by the Norfolk Southern engineer and the student engineer after the accident suggest that the engineer and the conductor were probably asleep before the train was placed into emergency braking. The engineer, when questioned by Safety Board investigators about whether he was asleep before the accident, refused to answer on grounds of self-incrimination. When asked by Norfolk Southern officials whether he or the conductor was asleep before the accident, the engineer responded, "Do I gotta say that?" The student engineer said that before the accident, the side of the locomotive cab occupied by the engineer and conductor was dark. He was unsure how long the light was out, noting "it could have been a half hour, it could have been an hour. I don't know." He was unable to state with certainty whether the engineer or conductor was asleep while the light was out, only that no communication occurred between crewmembers during that time.

The Safety Board believes that both the conductor and engineer were probably asleep before the conductor rose from his seat to answer the student engineer's question regarding their location. The fact that the engineer and conductor had not interacted with each other or with the student while in a dark environment, for perhaps up to an hour, at a time of day known for reduced alertness, suggests that both individuals were disengaged from their environment and were probably asleep. Furthermore, after the accident, the

engineer stated that he was comfortable with the student engineer's performance during the trip, a belief that may have caused him to relax direct observation of the student engineer after departing Detroit. The possibility that one or both of these crewmembers were asleep is particularly compelling given that the engineer was unable to explain how or why he did not observe signal 111. The engineer's statement that the conductor called the approach signal at MP 111 is inconsistent with the student engineer's testimony that the engineer and conductor did not call the signal at that location and that no communication occurred between crewmembers during that time. Even if the signal lights were out when the Norfolk Southern train approached MP 111, an alert and vigilant crewmember would have known the physical location of that signal and informed the student engineer of its status.

The Safety Board finds that the engineer's inability to explain missing the signal at MP 111, in the context of his equivocal responses about whether he was asleep before the accident and his sitting still in a darkened environment, raises valid questions about his state of alertness before the accident. The Safety Board therefore concludes that the engineer and conductor failed to observe and call signal 111 because they were distracted, inattentive, or possibly asleep.

Adequacy of Methods for Ensuring Compliance With Operating Rules

During the previous trip from Peru to Detroit, company policies were not followed, and as a result, the student engineer was operating a train with an engineer who was not coach trained. However, the Safety Board considers this lapse to be less significant than what happened after the crew departed Detroit for the accident trip. No unusual events occurred from the time the train departed Detroit until several minutes before the accident, which may have led the engineer and conductor to be overly confident about the student engineer's abilities and may have caused them to relax their vigilance even though they knew the student engineer was not qualified on the physical characteristics of the territory. The possibility that the crewmembers may have relied too heavily on the student engineer's abilities is compelling, given that both the engineer and conductor were reading books during the trip and were probably asleep at the time the student engineer realized his predicament.

In addition, no one individual was responsible for supervising the student engineer. Although the engineer testified that the student engineer was "more his [the conductor's] boy than mine" and that the conductor "convinced me to let him [the student engineer] run the engine in the first place," he also reported that he had been sufficiently impressed with the student engineer's abilities during the preceding trip from Peru to allow the student to run the train. The statements point to confusion concerning who was responsible for the student engineer.

According to Norfolk Southern operating rule 601, engineers are responsible for train handling and care of the equipment and, by extension, for a student's operation of the train. According to operating rule 581, conductors are in charge of all train crewmembers

and are responsible for enforcing rules and instructions. The Safety Board therefore concludes that the engineer, as the individual responsible for train handling and care, and the conductor, as the individual responsible for ensuring that rules and instructions are followed, disregarded their responsibilities during the accident trip. The Safety Board further concludes that this accident could have been avoided had the conductor and engineer complied with Norfolk Southern rules and instructions to include: observing and confirming all signal aspects; actively supervising the student engineer, particularly one who was unfamiliar with the territory; and not reading or engaging in other distracting activities. Therefore, the Safety Board believes that Norfolk Southern should develop and implement methods to improve employee compliance with company rules and instructions.

One compliance issue that was pivotal to this accident and that Norfolk Southern could address promptly concerns operating rule 34. According to testimony by both the engineer and the student engineer, the conductor stated it was crew practice not to call clear signals, an instruction that Norfolk Southern officials stated is in violation of the rule 34 requirement to call all signals. The Norfolk Southern Lake Division had a sufficient record for conducting tests and observations for operating rule compliance, including rule 34 compliance, and reported a low failure rate during testing. But such data may be misleading because a supervisor must be on board the train and witness noncompliance for a failure to result. That the train crew could routinely ignore this operating rule, despite the Lake Division's conscientious testing and observation program and even after the conductor had received a letter of reprimand within a year of the accident for violating that operating rule, strongly argues that an operating rule alone will not guarantee that signals are called.

Norfolk Southern does not maintain a record of in-cab communication of signals. Two other railroads, the Burlington Northern Santa Fe Railway Company (BNSF) and the Union Pacific Railroad (UP), require that signal aspects, time, and speed be noted on a form. (See appendix C for the UP form.) The BNSF requires that these forms be submitted at the end of each trip as directed by the applicable division superintendent. The UP requires that conductors maintain the forms for five trips and keep them in their possession while on duty.

The railroad industry already has requirements for recording crewmember actions or events during a trip, such as those for drug and alcohol testing under 49 CFR 219 and the use of event recorders under 49 CFR 229.135. These measures provide an after-the-fact record, reinforcing desired behavior by ensuring crewmember accountability. In addition, tasking crewmembers to keep a record of signals observed would enhance train crew coordination by ensuring that crewmembers communicate during a trip.

The Safety Board concludes that having procedures to actively engage crewmembers in observing and confirming all signal aspects, such as recording the aspects, would make it more likely that train crews call signals in compliance with the operating rules. Therefore, the Safety Board believes that Norfolk Southern should develop and implement procedures that actively engage crewmembers in observing and confirming all signal aspects.

Adequacy of the Locomotive Engineer Training Program

The Safety Board evaluated the effectiveness of the on-the-job portion of Norfolk Southern's locomotive engineer training program principally in the context of the relationship between the student engineer and the engineer. During the accident trip and during the preceding trip from Peru to Detroit, the student engineer did not follow company policy by failing to ascertain whether the engineer was coach trained. That a student engineer was ultimately paired with an engineer who was not coach trained clearly illustrates that despite the company's assertion to the contrary, Norfolk Southern procedures designed to prevent such situations have not worked.

The student engineer said after the accident that he did not realize or had forgotten that he could not operate a train without a coach-trained engineer. However, even if the student had been aware of the restriction, he could not have verified the engineer's status until reporting for duty because he did not receive the company's list of coach-trained engineers until several months after the accident.

The Safety Board determined that the form (appendix B) noting the restrictions on student engineers and signed by the student engineer on March 3, 1998, while developed and deemed appropriate for student engineers assigned to the Lake Division, was not being used systemwide. The System Road Foreman of Engines (SRFE) stated that the form was unique to the Lake Division and that other divisions used similar forms or dispensed similar information orally. The Safety Board concludes that allowing local variations in training requirements promotes operational inconsistencies and hinders uniform compliance with the student engineer training program.

Because Norfolk Southern provided information on the student engineer program to coach-trained engineers only and, in the Lake Division at the time of the accident, relied on student engineers to inform engineers of operating restrictions, it is unlikely that the engineer would have known that the student should not operate the train. According to the DRFE, a Superintendent's Notice was issued after the accident informing all Lake Division personnel of operating restrictions for student engineers. The Safety Board concludes that unless all Norfolk Southern operating personnel are informed of restrictions on the operation of trains by student engineers, a situation in which a student engineer operates a train without proper supervision could occur again. Therefore, the Safety Board believes that Norfolk Southern should inform all operating personnel of their responsibilities regarding student engineers.

Furthermore, the Safety Board is concerned that when the student engineer returned to the Lake Division, he received no feedback on his performance. The fact that the student received no oral or written feedback during this phase of his training is additional evidence that the locomotive engineer training program at the time of this accident was inadequate. The Safety Board regards timely feedback as an essential element in any training program for achieving and maintaining desired behavior consistent with stated policy; inadequate or no feedback degrades the training experience. Performance feedback, whether from a qualified engineer or a road foreman, should occur

throughout the training process. The Safety Board concludes that not providing feedback because the student engineer had not yet reached the point at which he was scheduled to be formally evaluated by a road foreman (that is, he had not worked in the Lake Division for 1 month) is inconsistent with the goals of effective training. The Safety Board further concludes that Norfolk Southern's oversight of student engineers during the on-the-job portion of training is inadequate. The Safety Board therefore believes that Norfolk Southern should assign supervisors dedicated exclusively to student engineers who will, at a minimum:

- meet with student engineers at the start of the on-the-job training phase to ensure that student engineers are aware of the conditions under which they can operate a train and that they know what to do if these conditions are not met;
- track the student engineer's daily train assignments, daily crew assignments, and performance evaluations; and
- provide timely feedback and advice to student engineers on a continuing basis.

The Safety Board evaluated the effectiveness of the classroom portion of Norfolk Southern's locomotive engineer training program principally in the context of whether the training adequately prepared the student for operational situations encountered during the accident trip. The investigation revealed that the student engineer had not been trained to operate a locomotive in the long-hood-forward configuration; in fact, the first time he had ever operated a locomotive in this configuration was the day before the accident.

Norfolk Southern Training Center personnel indicated that locomotive engineer training includes the fundamental concepts of locomotive and train operations. Classroom and laboratory activities are combined with daily hands-on simulated train operations using one full-motion and two stationary locomotive simulators. All three simulators are configured with the "short nose forward"; consequently, the view from the simulator is significantly less restricted than the view the student engineer had during the accident trip. Training Center personnel said that while students in training at McDonough may have the opportunity to operate a locomotive in the long-hood-forward configuration on the school's training track, the division is responsible for training student engineers on operational variations and conditions unique to the division, including operating locomotives in the long-hood-forward configuration.

The Safety Board disagrees with this approach to engineer training. An adequate training program should address all known or anticipated operational requirements systemwide. The idea that training should address operational requirements systemwide is particularly relevant considering the local variations in student engineer training requirements that were discussed earlier in this section. By delegating selected aspects of operational training to the divisions, the locomotive engineer training program does not equally prepare student engineers for situations encountered on the job. The Safety Board concludes that Norfolk Southern's engineer training program was not adequate to prepare student engineers to cope with all known or anticipated operational requirements systemwide, such as operating trains with the long hood forward. The Safety Board believes that Norfolk Southern should provide student engineers with formal training in

all known or anticipated operational requirements systemwide, including operating trains with the long hood forward.

The Safety Board considers aggressive oversight to be essential to any program, but particularly to a training program, because such oversight promotes compliance with company policy. Since the company's merger with Conrail in June, the number of engineers employed by the company has increased from the approximately 3,600 employed at the time of the accident to 5,003, according to Norfolk Southern's SRFE. The nearly 40-percent increase in the number of Norfolk Southern engineers since the company's acquisition of Conrail makes oversight of the training program even more critical.

The lack of oversight in this accident is particularly relevant considering the training improvements that Norfolk Southern stated it had implemented after a strikingly similar accident near Knox, Indiana, in 1991.[32] As was the case in this accident, the Knox investigation found deficiencies in crew coordination, communication, and cab discipline, prompting the Safety Board to make the following recommendation to Norfolk Southern:

R-92-09

> Review and revise your programs for traincrew supervision, locomotive cab discipline, and training of student engineers in light of the circumstances of this accident, and make necessary improvements.

In February 1993, the Safety Board classified this recommendation "Closed—Acceptable Action," based on the company's response that it had revised its training to emphasize the understanding of and compliance with operating rules and to emphasize the engineer's responsibility for safe and effective train handling. However, the circumstances of the Butler accident show that Norfolk Southern must explore additional ways to improve engineer training, both in the classroom and the field. In light of the deficiencies found in both the field and classroom portions of the locomotive engineer training, the Safety Board believes that Norfolk Southern should conduct a comprehensive assessment of the locomotive engineer training program and revise it, as necessary, to ensure that student engineers consistently operate with and are mentored by coach-trained engineers and that engineer training reflects actual operating conditions. In addition, the Safety Board believes that the FRA should review Norfolk Southern Corporation's 49 CFR 240 submission, *Certification of Locomotive Engineers*, specifically "Section 5: Training, Testing, and Evaluating Persons Not Previously Certified," to determine whether the company's training program is adequate for training new engineers and require that any deficiencies found be corrected.

[32] Railroad Accident/Incident Summary Report—*Knox, Indiana, September 17, 1991* (NTSB/RAR-92/02/SUM).

Importance of Train Crew Resource Management

The events leading up to this accident illustrate that effective crew coordination is imperative, especially when a crewmember is receiving on-the-job training. Throughout the accident trip, the engineer and conductor did not call clear signals. Had all signals been communicated in accordance with Norfolk Southern's operating rules, the student would have had a better sense of the train's location in unfamiliar territory. Based on the statements of the engineer and the student engineer, all crewmember communication ceased well before the train approached the interlocking at Butler. In fact, for at least 30 minutes before the accident, the student engineer operated the train independently of the engineer and conductor. Moreover, he could not utilize their experience to help determine his location until just before the train was placed into emergency braking because he had not been provided strategies for dealing with crewmembers who knowingly disregard carrier rules and procedures. The Safety Board therefore concludes that Norfolk Southern crew coordination, communication, and cab discipline were inadequate in the events leading up to this accident.

During the accident trip, the crewmembers' actions neither promoted compliance with the operating rules nor provided a positive model for the student to emulate. Norfolk Southern stated that student engineers could contact the dispatcher or road foreman to report problems such as the ones that occurred during the accident trip. However, an employee, particularly a trainee eager to gain operational experience, may be reluctant to challenge or report fellow crewmembers. The Safety Board concludes that Norfolk Southern lacks adequate safeguards to prevent student engineers from being placed in untenable situations in which rules and procedures are disregarded. The Safety Board believes that Norfolk Southern should provide employees, especially trainees, with effective strategies for dealing with crewmembers who knowingly disregard the operating rules.

One method of improving crew coordination and communication is through training. The Safety Board has long been a proponent of crew resource management (CRM) training in the aviation community and bridge resource management (BRM) training in the marine community. The goals of CRM and BRM are similar in that they promote safe operations by emphasizing the efficient use of all resources to achieve and maintain better coordination of activities. CRM and BRM training addresses critical areas, including:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority.

The principles of CRM and BRM could be used to develop train crew resource management (TCRM) training for the railroad industry. The Safety Board has investigated

several railroad accidents[33] that occurred because of inadequate communication, lack of discipline, and crewmembers' failure to function collectively as a team. In 1996, the Safety Board became aware of training developed by and for railroad employees of the former Southern Pacific Railroad (now the UP) and modeled after the training provided to crewmembers at American Airlines. The UP continues to provide this training to its employees and, since late 1998, has required all newly hired employees to receive it. Contact with several other Class I railroads revealed that they are not providing TCRM training. The Safety Board is not aware that the FRA has demonstrated an interest in exploring and developing TCRM principles and training for the industry.

The Safety Board concludes that this and other accidents investigated by the Safety Board demonstrate that railroad safety would be enhanced if crewmembers received TCRM training. Therefore, the Safety Board believes that Norfolk Southern, the Class I railroads and Amtrak, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union should develop, for all train crewmembers, TCRM training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority.

The Safety Board also believes that the FRA in cooperation with Norfolk Southern, the Class I railroads and Amtrak, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union should develop and require, for all train crewmembers, TCRM training that addresses these principles. The Safety Board is encouraged by the example of the UP and is optimistic that the pursuit of TCRM principles by Government, industry, and labor will facilitate safe and efficient railroad operations.

Adequacy of Signal Malfunction Reporting Procedures

The Norfolk Southern dispatching center in Fort Wayne receives and records signal malfunctions reported by train crews. After investigating the February and March 1998 reports of dark signal occurrences, the Norfolk Southern signal maintainer reported to the Norfolk Southern dispatching center that intermediate signal 111 was working properly. The signal maintainer also informed the dispatching center that the signal would

[33] Railroad Accident/Incident Summary Report—*Knox, Indiana, September 17, 1991* (NTSB/RAR-92/02/SUM); Railroad Accident/Incident Summary Report—*Derailment of Amtrak Train 87, Silver Meteor, in Palatka, Florida, on December 17, 1991* (NTSB/RAR-93/02/SUM); and Railroad Accident Report—*Collision and Derailment of Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Corporation Amtrak Train 29, near Silver Spring, Maryland, on February 16, 1996* (NTSB/RAR-97/02).

be monitored again. During interviews, the signal maintainer explained that monitoring consisted of acquiring downloads from the signal data recorder and examining the logs. However, no followup downloads were performed after either dark signal report. The Safety Board concludes that the Norfolk Southern Lake Division dispatching center lacked an effective procedure for identifying reported signal malfunctions of undetermined causes for further monitoring.

The majority of Class I railroad dispatching centers have full-time signal personnel working in their dispatching centers to handle all signal and grade crossing malfunction reports. The dispatchers forward such reports to these representatives, who record and track the status of the malfunctions and notify the necessary signal maintenance personnel to investigate and repair them. Having personnel technically knowledgeable in signal systems aids in prioritizing the investigation and repair of malfunctions that require immediate attention. Designated personnel not tasked with dispatching trains can also better and more thoroughly identify and track locations that have repeated malfunction reports and ensure that all available tools are used to repair the malfunctions and maintain the proper level of safety. The Safety Board believes Norfolk Southern should designate dedicated personnel to record and track all signal malfunctions and repairs in order to identify recurring, unresolved failures.

Adequate followup was crucial in the case of signal 111 because routine troubleshooting by a signal maintainer would not have identified the failed capacitors; they are on an electronic unit that the signal maintainer does not normally access. Further, during the investigation, even a complete field operational test of the electronic track circuit unit at signal 111 did not identify abnormalities. Only when the signal was observed going dark during the course of the investigation was the Electro Code 4 unit containing the lighting module removed and bench tested and the failed components subsequently identified.

Postaccident testing revealed that the failed capacitors also affected the signal data recorder at MP 111, causing it to record events even though no physical changes were occurring in the operational status at the signal location, thus rapidly filling the memory buffer and overwriting older recorded events. If a download of the log had been acquired before the accident, the number of events recorded in a relatively short time should have prompted the signal maintainer to find a cause for the abnormal readings. In addition, if the events occurred in the time span examined, close examination of the signal data logs may have revealed the random dark signal occurrences. Because of the absence of data relevant to the accident time frame and the randomness of the dark signal occurrences, the Safety Board concludes that the aspect displayed by intermediate signal 111 to the Norfolk Southern train just before the accident cannot be determined.

Electro Code 4 units, such as the one at signal 111, determine which aspects to display from the codes received from the tracks. These units supply energy to illuminate the signal lamps directly and cause all lamps to go dark if internal self-tests and microprocessor operations detect a loss or perceived loss of control over the lamp output. The voltage to the lamps ceases until the failure condition is corrected.

At signal 111, the failed capacitors allowed random noise (variations in voltage) into the signal lamp output used by the microprocessors to monitor operations, causing the lamp converters to shut down while the microprocessors performed an internal self-test to ensure the unit was operational before energizing any signal lamps. The Safety Board concludes that had Norfolk Southern's maintenance program responded to and corrected the twice-reported signal deficiencies at signal 111, the signal would not have continued to go dark intermittently.

Harmon Industries estimates that of the Electro Code 4 units manufactured from 1987 to 1988, approximately 25,000 are currently installed on the nation's railroads. The Safety Board concludes that although the product improvement announcement issued by Harmon Industries addresses the capacitor problem, replacement of the capacitors is not just an improvement but needs to be made a requirement for the safe operation of Electro Code 4 units. Therefore, the Safety Board believes that Harmon Industries should identify and contact all customers who purchased Electro Code 4 units manufactured from 1987 to 1988, and institute a systematic corrective program for the repair or replacement of faulty electrolytic capacitors. The Safety Board also believes that the FRA should direct Harmon Industries and the railroad carriers to identify and replace all faulty Electro Code 4 capacitors and that the FRA should ensure, through followup inspections, that corrective actions have been taken.

Continued Need for In-Cab Audible Recording Devices on Trains

As noted in the previous section, the absence of signal recorder data relevant to the accident time frame and the randomness of dark signal occurrences make it impossible to determine exactly what happened as the Norfolk Southern train approached intermediate signal 111. The Safety Board concludes that had the train been equipped with an in-cab voice recorder, recorded crew communications would have been available that could have provided valuable clues in reconstructing the accident.

The Safety Board, in its investigation of the 1996 Silver Spring accident involving Amtrak train 29 and Maryland Rail Commuter train 286, concluded that had crewmembers' voice communications been recorded, essential details about the circumstances of that accident could have been captured. Consequently, the Safety Board recommended that the FRA:

> R-97-9
>
> Amend 49 Code of Federal Regulations Part 229 to require the recording of train crewmembers' voice communications for exclusive use in accident investigations and with appropriate limitations on the public release of such recordings.

The FRA has acknowledged the Safety Board's recommendation but taken no action to date. On January 17, 1999, two Conrail trains collided in Bryan, Ohio, resulting in the deaths of all crewmembers on one of the trains. Because train crew communications were not recorded, reconstructing that accident will be extremely difficult. Accidents such as those in Butler, Silver Spring, and Bryan highlight the need for data beyond what can be

provided by a locomotive event recorder. Although event recorders have great utility in providing mechanical response data, such data cannot always answer the inevitable questions that arise in an investigation regarding the train crew's actions. The Safety Board plans to explore this issue further in its investigation of the Bryan collision.

Importance of Emergency Response Management in Hazardous Materials Accidents

The Safety Board has long been concerned about the emergency response management of railroad accidents involving hazardous materials. The Board, in its 1991 safety study[34] on transporting hazardous materials by rail, discussed how the lack of coordination between the railroads and communities on emergency response planning had presented major safety problems in nine accidents and incidents investigated between 1977 and 1987. The Safety Board subsequently issued the following recommendation to the Class I railroads:

> R-91-15
>
> Develop, implement, and keep current, in coordination with communities adjacent to your railroad yards and along your hazardous materials routes, written emergency response plans and procedures for handling releases of hazardous materials. The procedures should address, at a minimum, key railroad personnel and means of contact, procedures to identify the hazardous materials being transported, identification of resources for technical assistance that may be needed during the response effort, procedures for coordination of activities between railroad and emergency response personnel, and the conduct of disaster drills or other appropriate methods to test emergency response plans.

In July 1991, Norfolk Southern, replying on behalf of its affiliates, responded:

> Norfolk Southern Railway Company and its affiliated lines (NSR), including Norfolk and Western Railway, have developed and maintain an emergency action plan for hazardous materials incidents, which is available at all of our yard facilities and is on file in the offices of each master mechanic, division engineer, and freight agent. We maintain separate hazardous materials response plans at all of our substantial yard facilities which contain special information for those locations….

In December 1991, the Safety Board classified Safety Recommendation R-91-15 "Closed—Acceptable Action," based upon Norfolk Southern's subsequent letter elaborating on how emergency response procedures were being implemented. The November 1, 1991, letter noted that Norfolk Southern directs its emergency response coordination efforts toward all of the communities along its service routes, not just those with rail yards, to include sharing hazardous material response plans with localities,

[34] Safety Study—*Transport of Hazardous Materials by Rail* (NTSB/SS-91/01).

providing training for the smaller cities and towns along its routes, and providing personnel to serve on local emergency planning committees.

According to the Norfolk Southern Lake Division Supervisor, DeKalb County was not on the list of communities trained recently by Norfolk Southern in emergency response coordination. In this accident, local officials did not attempt to contact the railroad for assistance beyond asking the surviving Norfolk Southern crewmembers what substance the Norfolk Southern train carried. The company's lack of coordination with the community resulted in emergency response personnel taking an hour to identify a potentially hazardous substance and in two schools being closed unnecessarily. The Safety Board concludes that better coordination by Norfolk Southern with DeKalb County may have prevented the delay in identifying the possibly hazardous material transported on the Norfolk Southern train. In the Safety Board's opinion, such a situation is unacceptable, considering that more than 7 years have passed since Norfolk Southern stated it would coordinate emergency response plans with the communities along its service routes. The Safety Board is concerned that other communities may be exposed to similar risks from hazardous material releases and other rail emergencies because Norfolk Southern has not followed through on emergency response coordination. Therefore, the Safety Board believes that Norfolk Southern should conduct an audit to identify all communities through which it transports hazardous materials and, in coordination with those communities, develop, implement, and keep current written emergency response plans and procedures for handling hazardous material releases. The procedures should address, at a minimum, key railroad personnel and means of contact, procedures to identify the hazardous materials being transported, identification of resources for technical assistance that may be needed during the response effort, procedures for the coordination of activities between railroad and emergency response personnel, and the conduct of disaster drills or other methods to test emergency response plans. The Safety Board also believes that the DeKalb County Emergency Management Agency should contact Norfolk Southern Lake Division officials to provide and keep current, points of contact for emergency response coordination.

Conclusions

Findings

1. The following factors did not contribute to this accident: mechanical condition of the trains and track, weather, the operation of the Conrail signal system and the interlocking signal system, and alcohol or drug use by and qualifications of the train crew.

2. Norfolk Southern lacks adequate safeguards to prevent student engineers from being placed in untenable situations in which rules and procedures are disregarded.

3. Allowing local variations in training requirements promotes operational inconsistencies and hinders uniform compliance with the student engineer training program.

4. Unless all Norfolk Southern operating personnel are informed of restrictions on the operation of trains by student engineers, a situation in which a student engineer operates a train without proper supervision could occur again.

5. Norfolk Southern's engineer training program was not adequate to prepare student engineers to cope with all known or anticipated operational requirements systemwide, such as operating trains with the long hood forward.

6. Not providing feedback because the student engineer had not yet reached the point at which he was scheduled to be formally evaluated by a road foreman (that is, he had not worked in the Lake Division for 1 month) is inconsistent with the goals of effective training.

7. Norfolk Southern's oversight of student engineers during the on-the-job portion of training is inadequate.

8. Norfolk Southern crew coordination, communication, and cab discipline were inadequate in the events leading up to this accident.

9. The engineer, as the individual responsible for train handling and care, and the conductor, as the individual responsible for ensuring that rules and instructions are followed, disregarded their responsibilities during the accident trip.

10. This accident could have been avoided had the conductor and engineer complied with Norfolk Southern rules and instructions to include: observing and confirming all signal aspects; actively supervising the student engineer, particularly one who was unfamiliar with the territory; and not reading or engaging in other distracting activities.

11. Because of the engineer's and conductor's lack of vigilance and decision not to call clear signals, the crew of Norfolk Southern train 255L5 failed to react to either an approach or a possible dark signal at milepost 111.

12. Having procedures to actively engage crewmembers in observing and confirming all signal aspects, such as recording the aspects, would make it more likely that train crews call signals in compliance with the operating rules.

13. The engineer and conductor failed to observe and call signal 111 because they were distracted, inattentive, or possibly asleep.

14. A fully implemented positive train separation system would have prevented this accident.

15. This and other accidents investigated by the National Transportation Safety Board demonstrate that railroad safety would be enhanced if crewmembers received train crew resource management training.

16. The Norfolk Southern Lake Division dispatching center lacked an effective procedure for identifying reported signal malfunctions of undetermined causes for further monitoring.

17. Had Norfolk Southern's maintenance program responded to and corrected the twice-reported signal deficiencies at signal 111, the signal would not have continued to go dark intermittently.

18. Had the train been equipped with an in-cab voice recorder, recorded crew communications would have been available that could have provided valuable clues in reconstructing the accident.

19. Because of the absence of data relevant to the accident time frame and the randomness of the dark signal occurrences, the aspect displayed by intermediate signal 111 to the Norfolk Southern train just before the accident cannot be determined.

20. Although the product improvement announcement issued by Harmon Industries addresses the capacitor problem, replacement of the capacitors is not just an improvement but needs to be made a requirement for the safe operation of Electro Code 4 units.

21. The reduced visibility on the student's side of the cab as the train approached milepost 111, compounded by a possible dark signal and by the student engineer's lack of experience, may have caused the student to miss the signal and the reflectorized milepost marker.

22. Better coordination by Norfolk Southern with DeKalb County may have prevented the delay in identifying the possibly hazardous material transported on the Norfolk Southern train.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer and conductor of train 255L5 to comply with operating rules (specifically, their failure to observe and confirm signal aspects and their failure to continuously and directly supervise the student engineer) and the failure of Norfolk Southern Corporation to ensure employees' compliance with operating rules. Contributing to the accident was Norfolk Southern Corporation's failure to ensure that its locomotive engineer training program provided effective, timely training; oversight; and feedback to ensure that students were adequately prepared for operational situations. Also contributing to the probability of this accident occurring was the failure of Norfolk Southern Corporation's signal maintenance program to respond to a reported signal deficiency.

Recommendations

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

—to the Federal Railroad Administration:

Review Norfolk Southern Corporation's 49 *Code of Federal Regulations* 240 submission, *Certification of Locomotive Engineers*, specifically "Section 5: Training, Testing, and Evaluating Persons Not Previously Certified," to determine whether the company's training program is adequate for training new engineers and require that any deficiencies found be corrected. (R-99-12)

In cooperation with Class I railroads, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union, develop and require, for all train crewmembers, crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-13)

Direct Harmon Industries and the railroad carriers to identify and replace all faulty Electro Code 4 capacitors. Ensure, through followup inspections, that corrective actions have been taken. (R-99-14)

—to Norfolk Southern Corporation:

Develop and implement methods to improve employee compliance with company rules and instructions. (R-99-15)

Develop and implement procedures that actively engage crewmembers in observing and confirming all signal aspects. (R-99-16)

Inform all operating personnel of their responsibilities regarding student engineers. (R-99-17)

Assign supervisors dedicated exclusively to student engineers who will, at a minimum:

- meet with student engineers at the start of the on-the-job training phase to ensure that student engineers are aware of the conditions under which they can operate a train and that they know what to do if these conditions are not met;
- track the student engineer's daily train assignments, daily crew assignments, and performance evaluations; and
- provide timely feedback and advice to student engineers on a continuing basis. (R-99-18)

Provide student engineers with formal training in all known or anticipated operational requirements systemwide, including operating trains with the long hood forward. (R-99-19)

Conduct a comprehensive assessment of the locomotive engineer training program and revise it, as necessary, to ensure that student engineers consistently operate with and are mentored by coach-trained engineers and that engineer training reflects actual operating conditions. (R-99-20)

Provide employees, especially trainees, with effective strategies for dealing with crewmembers who knowingly disregard the operating rules. (R-99-21)

In cooperation with the Federal Railroad Administration, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union, develop, for all train crewmembers, crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-22)

Designate dedicated personnel to record and track all signal malfunctions and repairs in order to identify recurring, unresolved failures. (R-99-23)

Conduct an audit to identify all communities through which you transport hazardous materials and, in coordination with those communities, develop, implement, and keep current written emergency response plans and procedures for handling hazardous material releases. The procedures

should address, at a minimum, key railroad personnel and means of contact, procedures to identify the hazardous materials being transported, identification of resources for technical assistance that may be needed during the response effort, procedures for the coordination of activities between railroad and emergency response personnel, and the conduct of disaster drills or other methods to test emergency response plans. (R-99-24)

—to the Class I Railroads and Amtrak:

In cooperation with the Federal Railroad Administration, the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union, develop, for all train crewmembers, train crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-25)

—to the American Short Line and Regional Railroad Association:

In cooperation with the Federal Railroad Administration, the Class I railroads, the Brotherhood of Locomotive Engineers, and the United Transportation Union, develop, for all train crewmembers, train crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-26)

—to the Brotherhood of Locomotive Engineers:

In cooperation with the Federal Railroad Administration, the Class I railroads, the American Short Line and Regional Railroad Association, and the United Transportation Union, develop, for all train crewmembers, train crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-27)

—to the United Transportation Union:

In cooperation with the Federal Railroad Administration, the Class I railroads, the American Short Line and Regional Railroad Association, and the Brotherhood of Locomotive Engineers, develop, for all train crewmembers, train crew resource management training that addresses, at a minimum:

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-28)

—to Harmon Industries:

Identify and contact all customers who purchased Electro Code 4 units manufactured from 1987 to 1988, and institute a systematic corrective program for the repair or replacement of faulty electrolytic capacitors. (R-99-29)

—to the DeKalb County Emergency Management Agency:

Contact Norfolk Southern Lake Division officials to provide and keep current, points of contact for emergency response coordination. (R-99-30)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

JOHN A. HAMMERSCHMIDT
Member

ROBERT T. FRANCIS II
Vice Chairman

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

Adopted: July 13, 1999

John A. Hammerschmidt, Member, filed the following concurring and dissenting opinion on July 22, 1999:

Notation 7177

Member HAMMERSCHMIDT, concurring and dissenting:

I concur with most of the report, yet there are some parts of the analysis, conclusions, probable cause, and safety recommendations that do not appear to be substantiated by the prevailing evidence. My specific concerns and preferred language, which also apply to the analysis, are as follows:

Conclusions

7. Norfolk Southern's oversight of **the** student engineer~~s~~ **involved in this accident** during the on-the-job portion of **his** training **was** ~~is~~ inadequate.

8. **The coordination, communication, and cab discipline of the** Norfolk Southern **train crew in this accident were inadequate.** ~~crew coordination, communication, and cab discipline were inadequate in the events leading up to the accident.~~

11. **This conclusion is not entirely correct. A decision not to call CLEAR (green) signals is not applicable to this accident since the signal in question, signal 111, should have been displaying an APPROACH (yellow) signal or have been DARK (inoperative).**

12. **This conclusion could be deleted. NS has a rule (rule 34) requiring train crews to call all signals encountered over the radio, by both the name and indication of each signal, to inform other trains within the range of the radio transmission and operating in the same area of the train's location and the governing signal. Conclusion 18 covers the use of in-cab voice recorders, which can be used to monitor compliance with the rule as well as enhance all accident/incident investigations.**

13. The engineer and conductor failed to observe and call signal 111 because they were **either** distracted, **deliberately or involuntarily** inattentive, possibly asleep, or **because the signal was inoperative.**

15. **This conclusion is speculative; if included, it should state:**

~~This and other accidents investigated by the National Transportation Safety Board demonstrate that~~ Railroad safety **may** ~~would~~ be enhanced if ~~crewmembers received train crew resource management training.~~ railroads developed and implemented crew resource management programs similar to those used by other transportation modes.

Probable Cause

The accident investigation does not support the statement that the Norfolk Southern failed to ensure compliance with the operating rules. [The engineer's statement after the accident, and the engineer's and conductor's disciplinary records, indicate that these employees made deliberate decisions not to comply with the rule of calling signals as required (rule 34). However, in the past, when the engineer and conductor had been observed not calling signals by NS officials, action was taken. The NS program did not have the ability to detect deliberate noncompliance with rule 34. Compliance could be monitored if an in-cab voice recorder were in use.]

The accident offers no support that the failure of NS's training program to have an effective feedback system was contributory to this accident.

Recommendations

—to the Federal Railroad Administration:

In cooperation with ~~Class I railroads,~~ **the Association of American Railroads,** the American Short Line and Regional Railroad Association, the Brotherhood of Locomotive Engineers, and the United Transportation Union, ~~develop and require,~~ **evaluate the effectiveness of crew resource management training programs, or similar programs, used by other transportation modes and, as appropriate,**

encourage the railroads to develop similar programs to enhance railroad safety. ~~for all train crewmembers.~~ **The programs developed should address, at a minimum:**

- crewmember proficiency,
- situational awareness,
- effective communication and teamwork, and
- strategies for appropriately challenging and questioning authority. (R-99-13)

[*Change the corresponding recommendations accordingly—R-99-25 through -28. Recommendation R-99-25 should be to the Association of American Railroads, which will include all Class I carriers, including Amtrak.*]

[The accident investigation does not adequately define "crew resource management" or the effectiveness the training programs have had in other transportation modes. In addition, some railroads may have similar programs (UP and NS may have one of a different name), but the report does not acknowledge if any exist and if they do, how they work or their effectiveness.]

—to Norfolk Southern Corporation:

~~Develop and implement~~ **Evaluate the effectiveness of your current rules violation disciplinary** methods **and then implement the necessary changes** to improve employee compliance with company rules and instructions. (R-99-15)

Develop and implement procedures**, such as an in-cab voice recorder,** that **will** ~~actively engage~~ **motivate** crewmembers ~~in observing and confirming~~ **to observe and confirm** all signal aspects. (R-99-16)

this page intentionally left blank

Appendix A

Harmon Industries Bulletin on Electro Code 4 Units

Harmon INDUSTRIES

PIA 98-101

Product Improvement Announcement

Subsidiary: Electro Pneumatic Corporation **Date:** May 15, 1998

Equipment Affected: Electro Code 4 and Electro Code 4 *Plus* – 211S, 211SRP, and 212A modules

Reason for Change:

211S and 211SRP

The 211S and 211SRP modules are DC to DC converters that are used in Electro Code 4 and Electro Code 4 *Plus* Intermediate signal units. These modules provide isolated battery for signal lighting circuits and are located in the top of the chassis housing behind the front panel. A resistor in the module's mid stage driver circuit may be subject to excessive heating due to heavy lamp load and/or continuous duty cycle of the lamp lighting circuits. Eventually, this resistor can fail open. In the event this circumstance occurs, excessive noise can be passed through the converters to the balance of the lamp lighting circuits. Random noise on a lamp output can be interpreted by the dual microprocessors as false energy. In response, the processors will turn the converters off, resulting in a dark signal for a period lasting approximately 40 seconds. Ultimately, the processors will attempt to reinitialize the converters and restore the signal lighting. The frequency of the dark signal occurrence depends on many variables and may be recognized many times during a single day, or sporadically during the course of one or several months.

212A

The 212A module is also part of the signal lighting circuits within Electro Code 4 and Electro Code 4 *Plus* equipment. AC signals from the processor modules are combined on the 212A to provide the excitation voltages to the 211 converter modules. It has been recognized that several of the electrolytic capacitors on the 212A modules have failed, resulting in symmetry distortion of the AC signal passed to the 211 modules. This distortion may exaggerate the noise condition as described with the 211S and 211SRP above.

PIA 98-101

Benefit: Harmon recommends an upgrade to the 211S, 211SRP, and 212A modules that will enhance signal lighting performance and reliability.

On the 211S and 211SRP modules, several components in addition to the resistor described above, will be replaced and added to the base design. This upgrade offer applies only to 211S and 211SRP converter modules. The original 211, 211A, 211R, and 211H modules are not affected. 211S and 211SRP modules manufactured between March 1994 and March 1998 are subject to this program. The chassis serial number and date code can be used to identify the upgrade candidates. The serial number appears on the left side of the chassis. The date code is represented by either a seven or eight-digit number. In a seven-digit date code, the first number represents the month and the second and third digits represent the year. In an eight-digit date code, the first two digits represent the month and the third and forth digits represent the year. Modified equipment can be identified by revision level stickers applied to the component side of the module. The 211S module can be identified by the minimum revision level E. The 211SRP can be identified by the minimum revision level A.

The 212A modules can be upgraded by replacing the electrolytic capacitors on the modules. This upgrade will increase reliability and longevity of the modules. Revised equipment can be identified by a modification revision level sticker located on the component side of the module bearing the letter C. This upgrade program applies to all 212A modules including Intermediate and End of Siding units.

All modules identified in the bulletin are offered for upgrade at no charge. Modules can be sent to the Harmon Riverside Repair and Return Department to receive the upgrade. Beginning inventory will be offered to start a rotation program. Seed modules and installation instructions will be offered. Components and modification instructions will also be offered to customers who prefer to modify their equipment. This no charge offer will extend through December 31, 1999.

Equipment and requests can be sent to: Harmon Industries Riverside Operations
Attention Repair and Return
7337 Central Avenue
Riverside, CA 92504
Phone: 800-854-4752

Appendix B

Norfolk Southern Lake Division
Student Engineer Form

(HL) Jake Hand

MAR-4-95 1ST

STUDENT ENGINEER - NAME: ANTHONY G. LOUROS DATE: MAR 3, 1998

1. Will mark off only with permission of Road Foreman of District where training.
   a. If there is an emergency may mark off and take care of it - informing RFE as soon as possible.
2. Will operate train with regular assigned engineer.
   a. Can operate with a COACH trained engineer who has been working at least one year. Must not switch assigned engineer unless okayed by RFE.
3. If regular engineer marks off - go with place.
4. If Pool turn is dropped - go with next turn that does not have a student engineer.
5. Progress reports for student engineer will be turned in with engineer's timeslip - to RFE of District.
6. Keep running total of assignments worked - have available
7. Keep supply of forms - can make copies a yard offices.
8. Stay marked up - IF YOU ARE NOT CALLED IN 24-30 HOURS CONTACT RFE.
9. Rest Day - will be taken only on Sunday or Monday unless arrangements have been made with RFE.

RFE: T. J. BOWN - Bellevue, Districts = Toledo - Fostoria - Lima
→ D. J. BOSTEK - Fort Wayne, Districts = Detroit - Huntington - Ann Arbor
A. L. THOMASON - Chicago, Districts = Chicago - Fort Wayne - AMC
T. S. SCHAEFFER - Portsmouth, Districts = Columbus/Sandusky - Cincinnati
W. L. COTTENGIM - Conneaut, Districts = Buffalo - Cleveland
W. A. WALKER - Muncie, Districts = Frankfort - New Castle
J. P. ONEST - Fort Wayne - Division
→ CL Page

I acknowledge understanding of these terms and conditions:

SIGNATURE, STUDENT ENGINEER

299

ATTACHMENT 3

Appendix C

UP Signal Recording Form

UNION PACIFIC RAILROAD

CONDUCTOR REPORT

This report must be completed by the Conductor of road freight trains on each trip or tour of duty. Conductors must keep reports in their possession of the last 5 round trips, which must be presented to managers upon request. Report all signals more restrictive than Clear (abbreviations may be used). Report all Train Defect Detector (TDD) announcements. Report other train delays.

Subdivision: ____________ Train/Job ID: ____________

Conductor: ____________ Engineer: ____________

Departure Date/Time: ____________ Arrival Date/Time: ____________

Location	Signal Aspect or TDD Announcement	Time	Comments & Other Delays

Acronyms and Abbreviations

Amtrak	National Railroad Passenger Corporation
BNSF	Burlington Northern Santa Fe Railway Company
BRM	bridge resource management
CFR	*Code of Federal Regulations*
CHEMTREC	Chemical Transportation Emergency Center
Conrail	Consolidated Rail Corporation
CP	control point
CRM	crew resource management
DRF	district road foreman
DRFE	Division Road Foreman of Engines
FRA	Federal Railroad Administration
MP	milepost
N&W	Norfolk and Western Railway Company
Norfolk Southern	Norfolk Southern Corporation
PCP	phencyclidine
PTS	positive train separation
SRFE	System Road Foreman of Engines
TCRM	train crew resource management
TCS	traffic control signal (system)
UP	Union Pacific Railroad