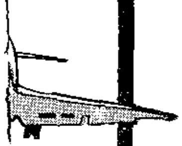
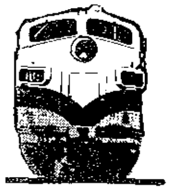


NATIONAL TRANSPORTATION SAFETY BOARD



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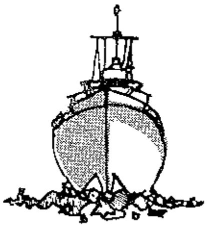
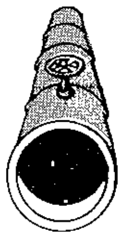


RAILROAD ACCIDENT REPORT

**REAR END COLLISION OF
CONRAIL COMMUTER TRAIN NO. 400
AND AMTRAK PASSENGER TRAIN NO. 60
SEABROOK, MARYLAND
JUNE 9, 1978**



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16. Abstract

About 6:40 p.m., on June 9, 1978, Conrail commuter train No. 400 struck Amtrak passenger train No. 60, which was slowing to stop at a grade crossing at Seabrook, Maryland. Eight cars of train No. 60 and the three head cars of train No. 400 derailed. Sixteen crewmembers and 160 passengers were injured, and damage was estimated to be $248,050.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 400 to perceive the train ahead and to properly apply the brakes in sufficient time to prevent a collision. Contributing to the accident was the failure of Amtrak to assure that the train crews were adequately trained. The causes of the large number of injuries in this relatively low-speed collision were the failure to maintain and service seats on the Amfleet equipment, and the injury-producing fixtures designed into the commuter cars.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: March 8, 1979

REAR END COLLISION OF CONRAIL COMMUTER TRAIN NO. 400 AND AMTRAK PASSENGER TRAIN NO. 60 SEABROOK, MARYLAND JUNE 9, 1978

SYNOPSIS

About 6:40 p.m., on June 9, 1978, Conrail commuter train No. 400 struck Amtrak passenger train No. 60, which was slowing to stop at a grade crossing at Seabrook, Maryland. Eight cars of train No. 60 and three cars of train No. 400 derailed. Sixteen crewmembers and 160 passengers were injured, and damage was estimated to be $248,050.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 400 to perceive the train ahead and to properly apply the brakes in sufficient time to prevent a collision. Contributing to the accident was the failure of Amtrak to assure that the train crews were adequately trained. The causes of the large number of injuries in this relatively low-speed collision were the failure to maintain and service seats on the Amfleet equipment, and the injury-producing fixtures designed into of the commuter cars.

INVESTIGATION

The Accident

On June 9, 1978, northbound Amtrak passenger train No. 60, the Montrealer, consisting of 1 locomotive unit and 14 cars departed Washington, D.C., at 6:11 p.m., 1 minute behind schedule. Predeparture brake tests, cab signal tests, and inspections disclosed no defects. Its first station stop was the Capital Beltway Station in Landover, Maryland, 10 miles north of Washington. Signal 128R, located south of the station, displayed an "approach" aspect which permitted train No. 60 to proceed into the station. The Landover operator ordered the train to remain at the station because a train ahead was having mechanical problems.

At 6:30 p.m., the operator advised the engineer of train No. 60 that the preceding train was moving and that train No. 60 could depart. As train No. 60 moved northward on track No. 2, the locomotive's low cooling air alarm sounded. The engineer was unable to reset the blower and this caused the engine to shut down. The engineer immediately began to apply the train brakes to stop the train. The train slowed to stop within the 128R signal block 1.59 miles beyond the Capital Beltway Station and 112 feet from the Seabrook (Maryland) Station.

Meanwhile, Conrail train No. 400, a northbound Washington-to-Baltimore commuter train, consisting of four self-propelled cars, had departed Washington on time at 6:15 p.m. Its first station stop was scheduled for Seabrook. Predeparture brake tests, cab signal tests, and inspections had disclosed no defects.

Signal 128R displayed a "stop" aspect as train No. 400 approached. The engineer said he saw the rear end of No. 60 disappear around a curve ahead as he stopped train No. 400. About 90 seconds after train No. 400 stopped, the operator lined the route for train No. 400 to move northward on track No. 2. Signal 128R then displayed a "stop-and-proceed" aspect and, as the train began to move northward, the cab signal displayed a "restricting" aspect. The engineer of train No. 400 stated that at a point about 3,168 feet north of signal 128R the cab signal changed to an "approach" aspect, instead of the "restricting" aspect it had displayed since the train passed signal 128R. He interpreted this to mean that the signal block to the Seabrook station was clear, and he said that he accelerated the train to about 35 mph to advance to the station.

Both engineers had successfully conducted radio tests with the Landover operator after they left Washington, as required by the operating rules. The engineer of train No. 60 said he used his radio to advise the Landover operator of his train's mechanical problem. This radio transmission was heard on a radio adjacent to the track by a person monitoring radio transmissions but was not heard by the Landover operator. The engineer of train No. 400 stated that he did not hear any radio communications from train No. 60 after he departed from signal 128R. Both he and the operator stated that radio reception became very poor and that there was some interference on one of the train radio channels shortly before the accident.

Once the engineer accelerated train No. 400, a passenger opened the door to the operating cab to talk to the engineer, who turned to speak to the passenger. They conversed as the train was traversing a 1° curve. Several times following the conversation with the passenger, the engineer turned to look into the passenger section of the car, passengers said.

The engineer stated that he first saw train No. 60 when it was about 2,000 feet ahead and moving very slowly on the same track. He said that he made a service brake application and, feeling no braking action, increased the application to full service. Still feeling no results, he placed the train brakes in emergency, he said. The train speed was not reduced significantly, however. When the engineer realized that train No. 400 would collide with train No. 60, he moved back into the first car to warn passengers. Several seconds later, train No. 400 struck the rear of train No. 60 while moving at an estimated speed of 15 mph.

A northbound train on track No. 2 beginning at signal 128R moves around a 1° right curve for 1,760 feet; the grade ascends at the rate of 0.62 percent. At this point the train enters a 2,290-foot tangent section. It then enters a 1° right curve for 1,654 feet on a 0.39 percent descending grade. The track is then tangent with the same rate of descending grade for 191 feet to the point of the collision. The tracks are elevated about 5 feet above the terrain on each side. Visibility of the engineer of a train approaching the collision point is about 1,770 feet because of track curvature and vegetation along the track. (See figure 1.)

Injuries to Persons

Injuries	Passengers	Crewmembers
Fatal	0	0
Nonfatal	160	16
None	142	3

Damage

The force of the collision derailed the eight rear cars of train No. 60. A baggage car, the last car in the train, was slightly damaged. The vestibule deck plate at the south end of the coach ahead of the baggage car buckled, and the door jammed. The north-end vestibule deck plate and center sills buckled. The sheet metal shell of the next coach ahead was slightly deformed. The next five cars were not damaged.

The first three cars of train No. 400 derailed. The first car was substantially damaged. The front-end collapsed rearward, and the roof buckled about 24 inches upward. Part of the center sill and coupler broke. The remaining center sill beam bent 7 inches to the right. The second car sustained only minor damage, and the third car was not damaged.

Damage costs were estimated as follows:

Train Equipment	\$240,000
Track	8,050
Total	\$248,050

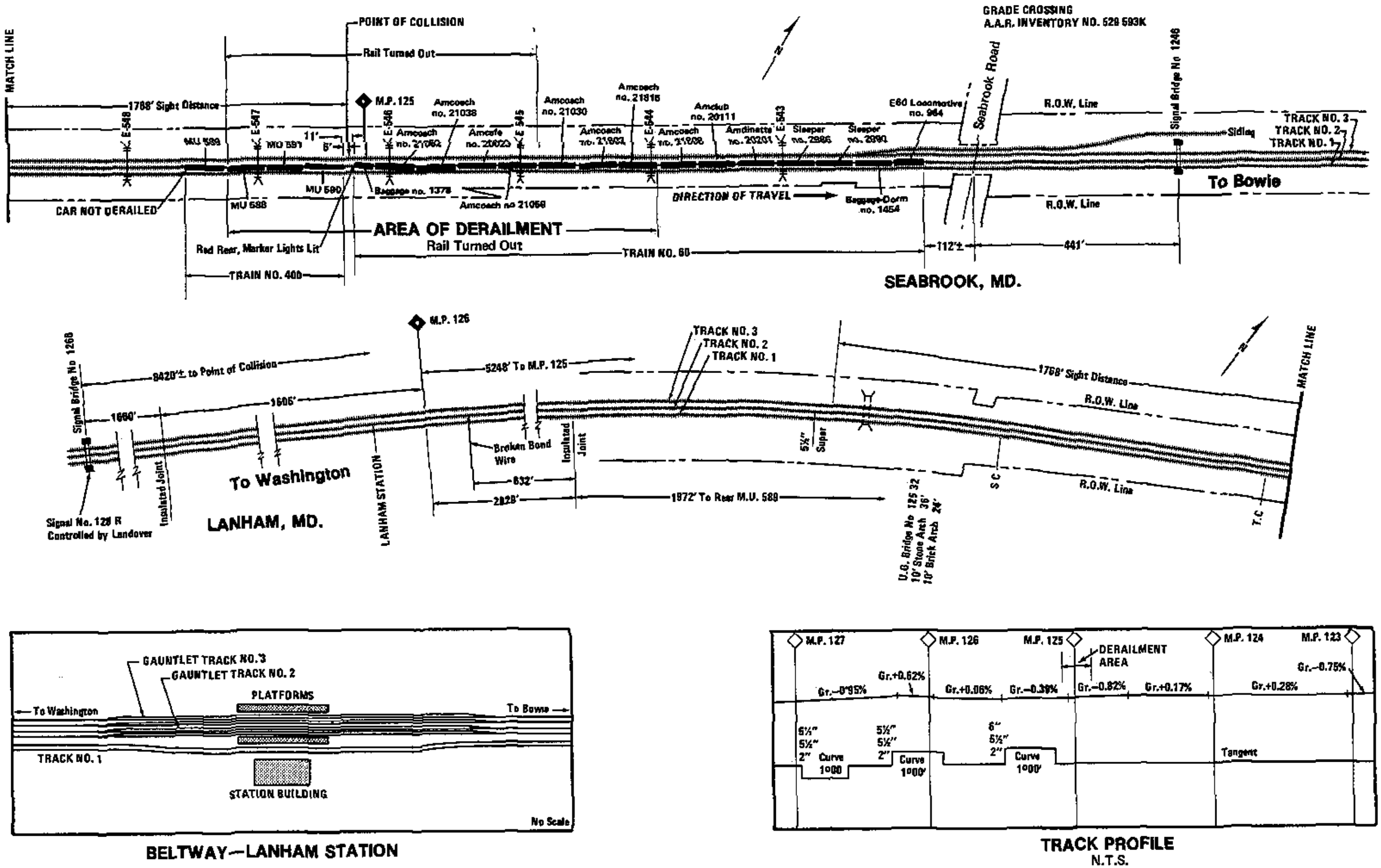


Figure 1. Plan view of accident site.

Crewmember Information

The eight crewmembers of train No. 60 had complied with the carrier's requirements for physical examinations, and operating rules and airbrake instruction. The engineer of train No. 60 had been an engineer for 5 years. He qualified for the position of engineer by attending classroom instructions for 6 weeks and receiving on-the-job training for 6 weeks. However, the training did not include instruction in the use of the E-60-type locomotive, which he was operating at the time of the accident. He had to rely on infrequent operating experience for knowledge of the locomotive.

The conductor of train No. 60 had been in train service for 35 years. All of his training had been on-the-job with no formal instruction. He had not been issued a copy of the Manual of Instructions for Conductors and Trainmen in Amtrak Service, which includes instructions on what a crewmember should do in an emergency. Train No. 60's crewmembers had been off duty for 30 hours 25 minutes before reporting for duty at 5:40 p.m., on June 9, 1978, in Washington.

The three crewmembers of train No. 400 also had complied with the carrier's requirements for physical examinations and operating rules and airbrake use instruction. The engineer of train No. 400 had been operating commuter cars between Baltimore and Washington for 6 years.

On May 1, 1978, older commuter cars in this service had been replaced with commuter cars leased from the New Jersey Department of Transportation (NJ DOT). That day, a Conrail road foreman accompanied the engineer of train No. 400 on the 1 hour 30 minute run and gave the engineer his only instruction in the use of the new equipment.

The conductor of train No. 400 had worked the commuter trains several times before the inauguration of the new cars. His first assignment on the NJ DOT cars was on train No. 400 on June 7, 8, and 9, 1978. He was not given familiarization instructions when he accepted the assignment. The flagman ticket collector on train No. 400 was regularly assigned this position.

The conductor evaluated the condition of each crewmember as they reported for duty on June 9, 1978, and he took no exceptions. Each had been off duty for 11 hours 12 minutes before reporting for duty at 6:35 a.m., at Baltimore, for the run to Washington. This portion of the trip required 54 minutes. During the 10 hours 33 minutes preceding the return trip from Washington, each had returned to his respective home in Baltimore, and, after returning to Washington, had reported for duty at 5:45 p.m. They had been on duty for 55 minutes when the accident occurred.

Train Information

Train No. 60 consisted of an E-60-type, electric locomotive, two baggage cars, one diner, one cafe car, one club car, two sleepers, and seven coaches. The locomotive was equipped with a speedometer, a safety control, an automatic train control, cab signals, a radio, and alarms in the locomotive control compartment to indicate component failure. If the alarm that indicated a low cooling air fault sounded, the locomotive engine would shut down unless the "low cooling air" and "blower" reset buttons were pressed simultaneously under the following conditions: pantograph up; catenary voltage applied; low cooling air fault present; and low air in main reservoir, compressor loaded.

The coaches of train No. 60 were manufactured by the Budd Company; each had a capacity of 84 passengers seated 4 abreast in 21 rows. Emergency window exits were provided at four locations, two on each side. Emergency exit through these windows was possible when the window stripping was peeled away and the pane of glass forced inward. Each coach had one end door which opened onto a vestibule. Each vestibule had a door on each side to enter or exit the car.

The seats in the coaches were manufactured to specifications furnished by the National Railroad Passenger Corporation (Amtrak) by AMI Industries, Inc., Amirail Division. The seats were manufactured as two-abreast units on one base frame. These two-seat units were designed to rotate 180° on their bases to face the direction of travel. Many of the seats rotated when the trains collided. When examined after the accident, many seats were found to have defective rotating and locking mechanisms. Many seats could not be locked into position. These cars had been in service 3 years without receiving any seat maintenance. No maintenance or service bulletins had been furnished to maintenance and servicing personnel.

Train No. 400 consisted of four self-propelled, electrically driven commuter cars. Each all-steel car was 85 feet long and had 4-wheel motor-driven trucks. Designed to operate in pairs, every two cars are semi-permanently coupled at one end. Each opposite end contained an operator's compartment. The couplers on these ends were fully automatic. Each car was equipped with a pneumatic braking system manufactured by the Westinghouse Air Brake Company.

The engineer of train No. 400 controlled all cars from the operator's compartment on the leading end of the train. A radio in each operating compartment allowed the engineer to communicate with crewmembers of other trains and tower operators. An intercom system enabled him to make announcements throughout the train. Each operator's compartment was provided with cab signals, but the cars were not equipped with automatic train control.

The commuter cars, constructed by the General Electric Company for the NJ DOT, were of two types. The "A" cars each had a capacity of 100 passengers seated 4 abreast in 25 rows. The "B" cars each had a capacity of 96 passengers, seated in the same manner except for a lavatory that replaced four seats. Two emergency-escape windows were located on each side of the cars. Emergency exit through these windows was possible when the window stripping was peeled away and the pane of glass pulled inward.

The passenger seats, designed by the General Electric Corporation, were low-back, "walk-over"-type seats, which permit the seat backs to be reversed so that a passenger can face the direction of travel. An unpadded metal strip bordered the tops and sides of the seats. (See figure 2.) A metal ticketholder is located on top of the seat backs. (See figure 3.) Overhead luggage racks did not have luggage restraints, and large metal hooks for hats and coats were attached to the bottom of the racks. (See figure 4.)

Each car had an end door which opened onto a vestibule, and passengers could move through doors on either side of the vestibule. Center doors on each side were used at stations having high platforms. The side doors could be used for emergency exit; however, the emergency operating mechanism was not identified and was contained behind a locked cabinet door. (See figure 5.) Operating instructions for this mechanism were on the inside of the locked panel door. (See figure 6.) This operating mechanism consists of a handle which, when moved to the "unlock" position, allows the doors to be opened manually. (See figure 7.) Representatives of the manufacturer and Amtrak said that the emergency mechanism was contained in a locked cabinet to prevent passengers from activating the device when there was an emergency.

The NJ DOT cars had a type-26, fully pneumatic brake system; the commuter cars used before May 1, 1978, had an electropneumatic system. To apply the brakes on the older cars the brake valve handle is moved counterclockwise from its far left position to the "service" position. In the service position, the train line pressure is reduced. When the desired amount of reduction is obtained, the handle must be moved clockwise to either the "lap" or "holding" position to maintain the brake application. If the brake valve remains in the service position, the air pressure in the train line will be depleted. (See figure 8.)

To apply the brakes on the NJ DOT cars, the handle of the B-1 self-lapping brake valve is moved from its far left position counterclockwise to the service position. The position in which the brake valve is placed in the service position determines the amount of reduction of air pressure in the train line and the amount of braking effort. The left side of the service position produces the least braking pressure while the right side produces the most braking pressure. It is not necessary to move this handle to another position to hold the brakes applied. To increase or lessen the braking effort the handle need only be moved in the proper direction within the service position. (See figure 8.)

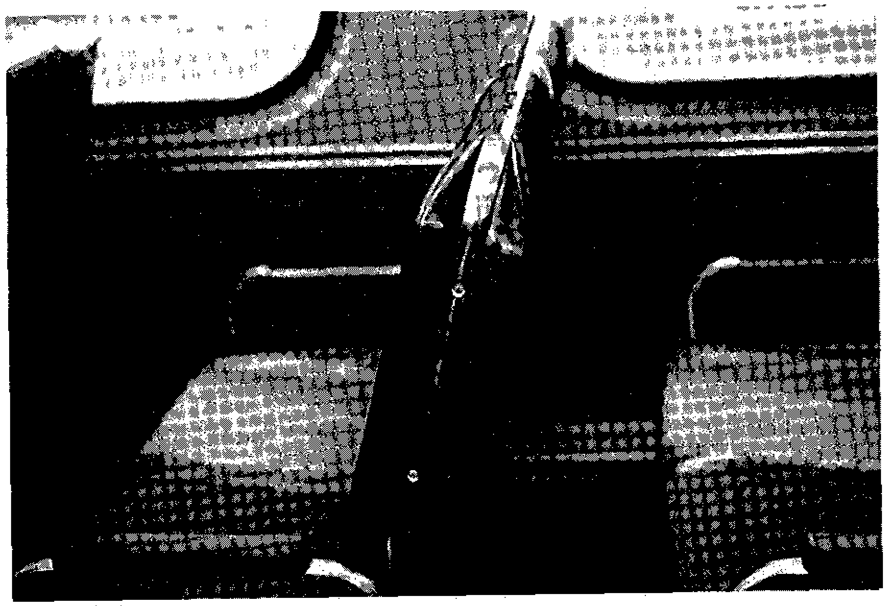


Figure 2. Seat with unpadded metal strip bordering top and side.

Figure 3. Metal ticketholder on top of seatback.

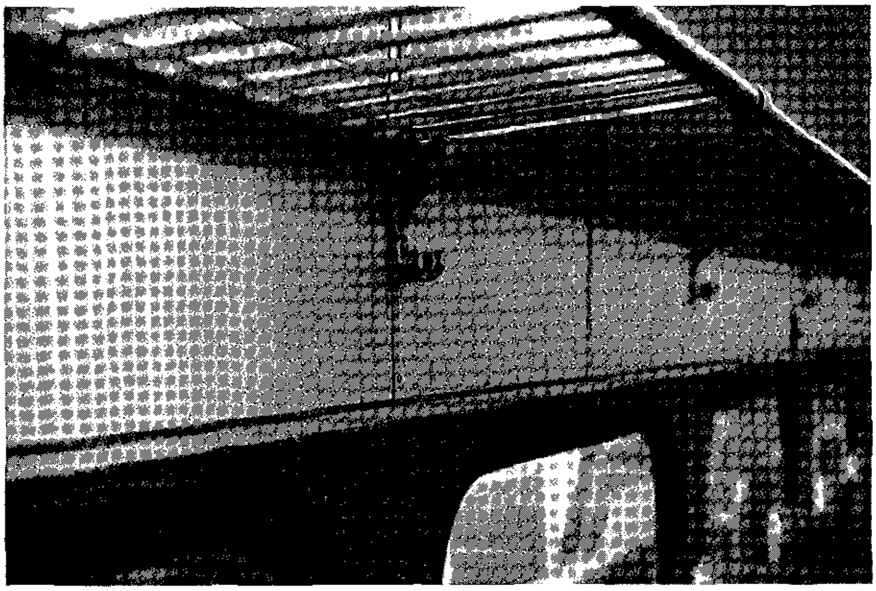


Figure 4. Large metal hooks for hats and coats.

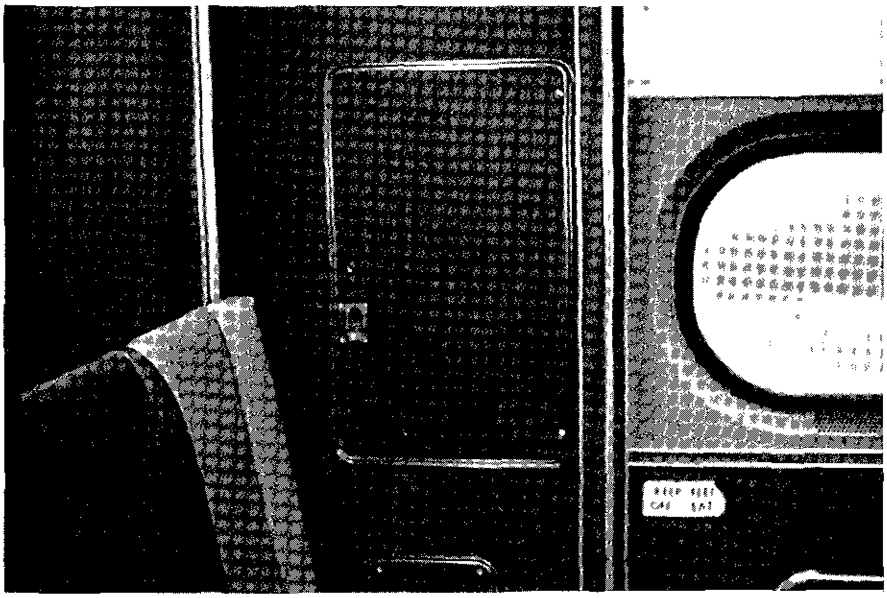


Figure 5. Cabinet door containing emergency operating door mechanism.

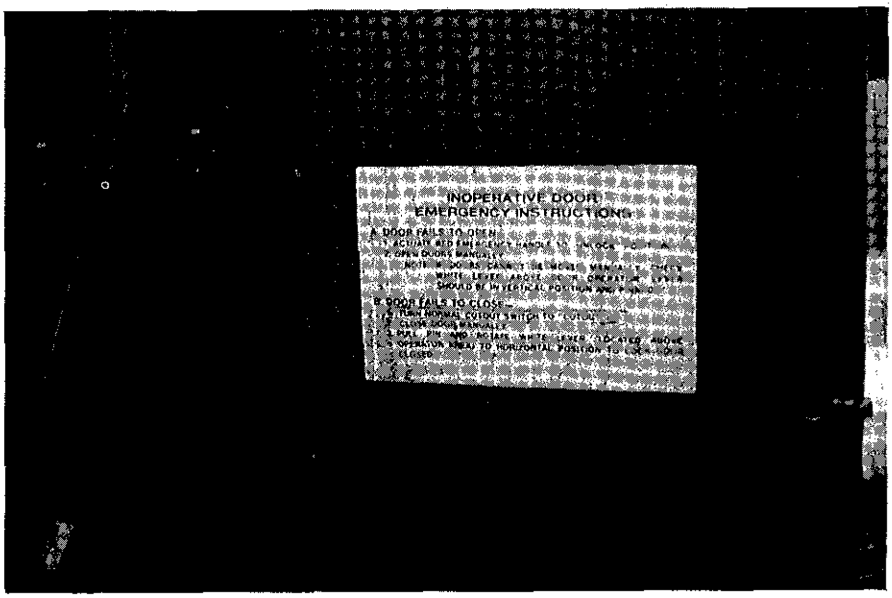


Figure 6. Operating instructions on inside of cabinet door.

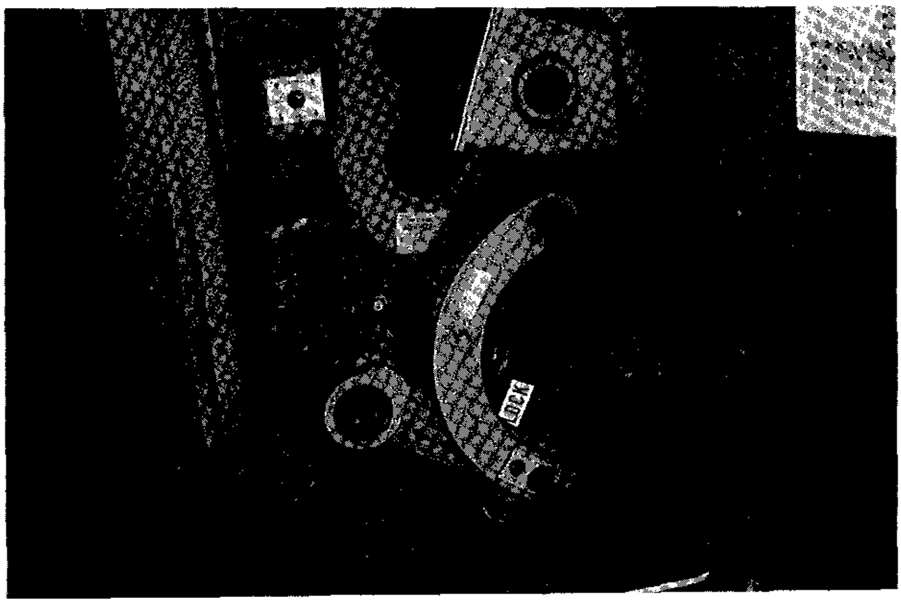
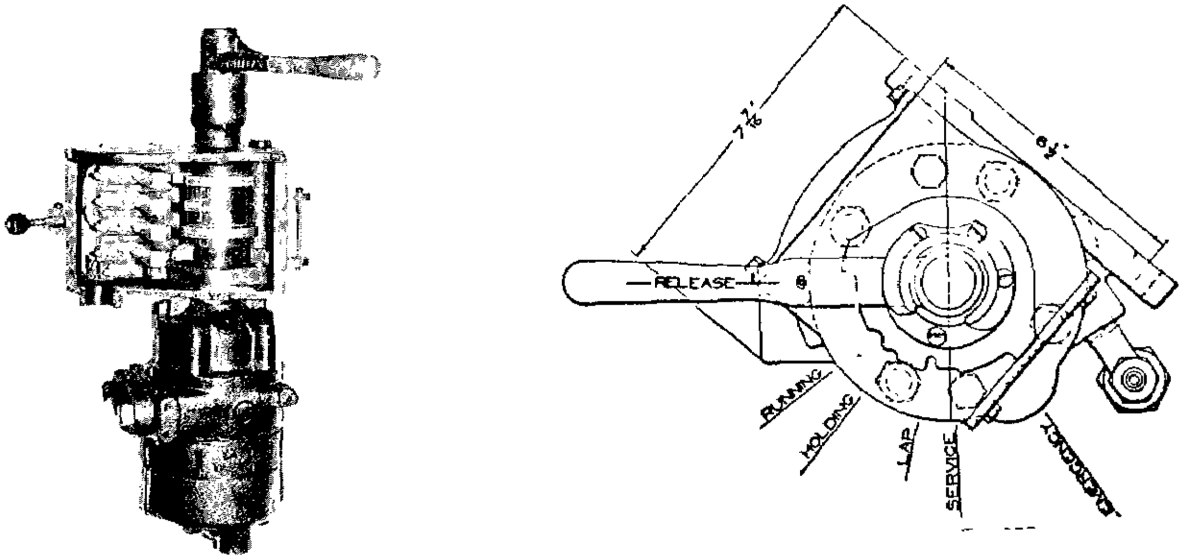
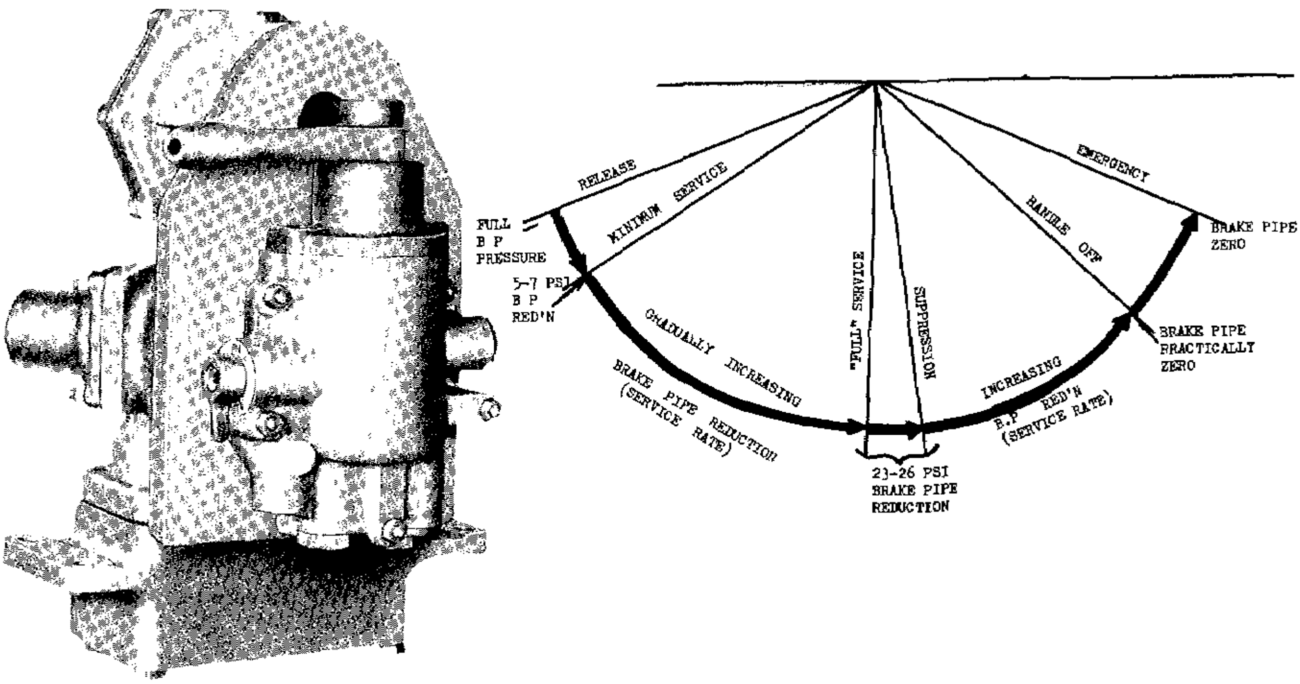


Figure 7. Center door emergency operating mechanism.



TYPICAL ELECTRO PNEUMATIC BRAKE VALVE



26-B-1 AUTOMATIC BRAKE VALVE

Figure 8. Brake valves and handle positions.

The emergency position on both brake valves is to the far right. The NJ DOT brake valve has a knob on the valve handle which strikes a shoulder on the valve quadrant and thereby prevents the handle from inadvertently being placed in the emergency position. To place the handle in emergency, the engineer must push the brake valve handle beyond this shoulder.

During the familiarization trip on the NJ DOT cars on May 1, 1978, the engineer of train No. 400 was seen, by the foreman of engines who was instructing him in operating this equipment, moving the brake valve into the service position and after obtaining the required braking pressure, moving the brake valve to the left as he would have done on the old cars. This caused the braking pressure to be reduced; the lack of braking caused him to run by a station.

The NJ DOT had purchased the commuter cars with funds supplied by the Urban Mass Transportation Administration of the U.S. DOT for operation in New Jersey. Amtrak first leased surplus NJ DOT cars from New Jersey and then subleased cars to the Maryland DOT for operation in the Baltimore-Washington commuter service. Conrail operates the commuter service under contract and both Maryland and the Federal government subsidize the service.

A catenary system providing 11,000-volt a.c. electrical power is used for train propulsion.

Method of Operation

Trains are operated over the three tracks in the accident area by signal indications of an automatic block signal system supplemented by locomotive cab signals. The three tracks were numbered consecutively, from east to west, Nos. 1, 2, and 3. The current of traffic was northward on tracks Nos. 1 and 2 and southward on track No. 3, but tracks Nos. 2 and 3 were signaled for movements in both directions.

The maximum authorized speeds on track No. 2 in the accident area were 110 mph for Metroliners and 80 mph for other passengers trains. Special timetable instructions permitted NJ DOT commuter cars to be operated at 110 mph on tracks Nos. 2 and 3 at Seabrook.

Meteorological Information

The accident occurred in clear weather, in daylight, and with light and variable winds. The temperature was 72° F.

Medical and Pathological Information

The injured occupants of train No. 60 sustained contusions and abrasions of the lower extremities, lacerations to the head and lower extremities, bruised ribs, neck and back sprains, and whiplash injuries. The passengers of train No. 400 received similar injuries. However, there was a higher incidence of head contusions and facial lacerations among the injured of train No. 400, and their neck and back injuries were not a result of whiplash.

Survival Aspects

Passengers in the first section of the lead car of train No. 400 were warned of the impending crash by the engineer and were able to brace themselves for the collision. However, passengers in the second section of the first car and those in the second car, who were not aware of the danger, were thrown forward into seatbacks. Many of the seatbacks collapsed and passengers fell across the armrests or onto the floor.

None of the occupants of train No. 60 were aware of the impending collision. First they were thrown back against their seats and then forward. Many seats swivelled, causing passengers to strike armrests and to be caught between seats. Some passengers were thrown to the floor and then pinned as seats rotated over them.

Passengers of both trains had little or no guidance in evacuating the trains and obtaining medical assistance. The conductor of train No. 400 did not know how to manually open the center side door, so many of the passengers had to be removed through the windows. Unaware of prescribed emergency procedures, crewmembers did little to help injured passengers. Passengers left the cars on their own initiative or at the direction of rescue personnel. Train crewmembers had not been given any formal training in the care of passengers in an emergency or derailment.

Emergency personnel were unable to open the center side doors of train No. 400 from the outside of the car because no means of operating the doors on the outside had been provided. They were also unable to open the center side doors from the inside because the cabinet containing the operating mechanism was unmarked and they were unfamiliar with this equipment. Amtrak and Conrail had not provided training and familiarization for railroad emergencies to local rescue organizations.

Tests and Research

A train consisting of four cars of the type that comprised train No. 400 was used for sight and stopping distance tests at the scene. Investigators determined that the engineer of train No. 400 could have first seen train No. 60 when they were 1,768 feet apart. Traveling at 70 mph, the engineer of the test train placed the brakes in emergency when it was 1,768 feet from the collision point, and the train stopped 90 feet short of the collision point. In another test conducted at 35 mph, the speed at which the engineer of train No. 400 said his train was traveling, the brakes were applied in service at the first point of visibility and the train stopped 1,258 feet short of the collision point.

The airbrakes of the four cars of train No. 400 were tested and found to function as designed. When examined after the accident, neither the wheels on the cars of train No. 400 nor the rails behind the train showed indications of heavy braking.

After the accident, the controller of train No. 400 was found in the "off" position, and the brake valve handle was in the "handle off" position. No defects in the master controller of train No. 400 were found. However, complete operating tests could not be conducted because related control wiring was severed in the accident.

The wayside and cab signal aspects displayed are determined from decoded pulsed 100-hertz a.c. voltage at either 180, 120, 75, or zero pulses per minute, depending on the track occupancy/integrity ahead. The information for the cab signals is picked up inductively from the rails by equipment on-board the locomotive.

The cab signal equipment from train No. 400 was tested at the Amtrak Shop in Wilmington, Delaware, and at the General Railway Signal Laboratory in Rochester, New York. During this testing, it was noted that when the code rate was changed from 180 to 75 and then to zero, the cab signal aspect displayed "approach" as if it were continually receiving a 75 code rate. Tests were later conducted using the same type control equipment from another car. Both sets of equipment performed in the same manner, which indicated that the fault could be a result of improper design and not just a component failure.

As a result of the findings of the tests at Wilmington, the National Transportation Safety Board issued Recommendations R-78-37 through -41 on June 23 and 27, 1978, (see pages 20 and 21) to insure the safe operation of trains while the investigation continued.

Subsequent testing by the General Railway Signal Company determined that the cause of the improper response was the critical values of an LC-tuned circuit in one of the stages of the "120" decoder unit which could react to a 100-hertz current. When the 100-hertz carrier current in the narrow range 1.25a to 1.35a was present in the rails and was picked up by the cab signal pickup coils, it triggered an oscillatory condition in the amplifier which was self-sustaining. It was found that a pole-changing network composed of solid-state circuitry, alternately changing the voltage polarity from positive to negative, allowed the oscillations to couple into the decoding unit and produce the undesired condition. This coupling provided enough energy to keep the relays energized and caused the cab signal to display an "approach" aspect instead of the "restricting" aspect in the zero mode.

Tests conducted on the cab signal control equipment could not reproduce the same failure described by the engineer of train No. 400; he said the cab signal aspect changed from "restricting" to "approach" when it should have remained at "restricting." Damage to train No. 400 caused by the collision made it impossible to use the car equipment in the tests.

A broken rail bond wire was found at a track rail joint approximately 5,462 feet north of signal 128R. A condition that affects the conductivity of one rail changes the impedance of the return path for the traction motor return current. This creates an unbalance in the traction motor return current from rail to rail. (See appendix C.) Even though the alleged cab signal failure could not be reproduced after the accident, the test report stated that an unbalance current could have caused the cab signal to change from "restricting" to "approach." However, the report said that the cab signal change would have been "short" because the necessary mechanics to have maintained the cab signal at "approach" did not exist through the signal block governed by signal 128R.

The undamaged radio equipment on both trains and in the Landover Tower was tested and found to operate properly. All radios produced more than adequate signals for satisfactory communication.

Tests indicated that the low cooling air fault that occurred on the locomotive of train No. 60 was caused by low voltage from the locomotive transformer under high acceleration conditions.

ANALYSIS

The Accident

The engineer's inability to reset the blower on train No. 60 can be attributed primarily to his lack of training on the E-60-type locomotive. With little operating experience on the E-60-type locomotive, he was not prepared for the locomotive mechanical problem and was forced to stop the train.

The engineer of train No. 400 and the Landover operator said that there was interference on one of the radio channels and that reception was poor shortly before the accident. Even though postaccident tests of the undamaged radio equipment showed it was operating properly, the Safety Board concludes that interference probably did prevent both men from receiving the report of the engineer of train No. 60 that he was stopping his train. Had the engineer of train No. 400 been able to hear train No. 60's radio transmission, he would have been alerted to the train standing in the signal block and should have realized that the cab signal, if displaying an "approach" aspect, was not displaying the proper indication.

Train No. 60 was scheduled to depart Washington 5 minutes ahead of train No. 400. On the day of the accident, train No. 60 departed only 4 minutes ahead of train No. 400. Though train No. 60 was scheduled to stop at the Capital Beltway Station, train No. 400 was not scheduled to stop until Seabrook, 1.3 miles beyond. Therefore, train No. 400 consistently operated on restrictive signal indications, especially through the accident area. The engineer of train No. 400 probably was anticipating an "approach" aspect on the cab signal equipment as he advanced beyond signal 128R, because train No. 60 usually had exited the signal block by this time. This aspect told the engineer that the signal block to Seabrook was clear and that he could move forward to make his station stop without interference. Since this was a daily practice, the engineer was used to progressing unimpeded to the station. On the day of the accident, the engineer of train No. 400 stated that he received an "approach" aspect on the cab signal before accelerating his train for the run to the Seabrook Station. A "restricting" cab signal aspect should be displayed when another train is in the same block.

The repetitiveness of this schedule and the daily practice of following on restrictive signals could have led the engineer to anticipate the upcoming, more favorable aspect he normally received. Although the Board believes that engineers should operate trains in strict accordance with signal indications, the restrictive signals in this case could have lost their slow movement connotation for the engineer, who no longer operated his train predisposed mentally to stop short of the train ahead. Better planning and careful attention to scheduling would give more time separation between trains and would discourage the development of a restricted speed operation such as developed at Seabrook.

A cab signal aspect which momentarily changes to a less favorable aspect is described as a cab signal "flip" and is not unusual. A cab signal aspect which momentarily changes to a more favorable aspect is very unusual, however; occurrences of this type are identified as cab signal failures. The cab signal failure as described by the engineer of train No. 400 could occur if stray or noise voltage were induced into the cab signal equipment. The investigation revealed a rail joint with a broken bond wire at a point north of signal 128R. This rail joint was located near where the engineer claims to have received the "approach" aspect. This broken rail joint bond wire could have created a condition that caused an unbalance in the return traction current, which may have possibly caused a cab signal failure as described above. Subsequent testing at Seabrook of the track and wayside signals revealed that the necessary conditions did not exist at that time to have sustained the "approach" aspect in the cab signal, however.

On June 16, 1976, the Safety Board recommended (R-76-31) that the Federal Railroad Administration (FRA) observe a statistically adequate sample of trains equipped with cab signals to establish the reliability of the system and take appropriate remedial action based on these findings. The FRA responded on February 16, 1978, that based on observations, it believes the existing cab signal systems are adequate and reliable. However, since a design fault that results in an oscillation of the amplifier was found in testing the cab signal equipment involved in this accident, the Safety Board concludes that the FRA should reopen the study on the reliability of cab signal systems.

Sight distance tests indicated that the engineer should have been able to stop train No. 400 short of the collision point even at a speed of 70 mph if he had full braking capability. His description of the braking action on the train and the tests of brake equipment indicated that the brake equipment functioned properly. However, the Safety Board believes that a key element in this accident is the dissimilarity in the operation of the brake valve handles in the NJ DOT cars and the older cars used before May 1, 1978.

The engineer of train No. 400 apparently did not see train No. 60 when it first became visible. When he did see the train, he apparently attempted to brake this train as he had braked the trains with the older cars, which were equipped with electropneumatic brakes. Those cars required the engineer to maneuver the brake valve handle to the left between the service application position and the electric holding or lap positions to maintain the application of the brakes. To increase the braking power, he had to maneuver the brake handle through the same sequence.

If the engineer operated the brake equipment on the NJ DOT car, in use at the time of the accident, in the same manner as he had operated the electropneumatic brake equipment on the older train, each movement to the left would have reduced or released the brake application. During the engineer's familiarization trip, he used this new brake valve improperly; he used it in the same manner as the older electropneumatic brake valve. Because of the lack of evidence of heavy braking on the wheels of train No. 400 or on the rails behind the train, and the position of the brake valve after the accident, the Safety Board concludes that the engineer did not apply the service brake properly and that an emergency brake application was not made.

One of the basic problems in learning a new skill is to prevent older or well-established habits or skills from interfering. The available evidence from this accident suggests a classic example of habit interference in the engineer's actions when he attempted to brake the train to avoid a collision. Confronted suddenly with a need for heavy braking action, the engineer could have reacted by applying the brakes in the intermittent manner most familiar to him through 6 years of experience in operating the older electropneumatic system. During normal service operations his relatively limited recent experience and limited training in the operation of the newer brake system probably enabled him to operate the brake system satisfactorily; nevertheless, the Safety Board believes that in this emergency situation the engineer's older habit pattern probably prevailed.

Survival Aspects

In this accident, 160 passengers and 16 crewmembers aboard the trains were injured. Passengers aboard train No. 60 were injured when the seats rotated because of defective locking mechanisms. Amtrak had not issued any instructions to its employees for the maintenance of the Amcoach seats; therefore, the seats had not been given any service maintenance. The Safety Board believes that if the seats of the Amfleet cars had been maintained so that they properly locked in position, injuries on train No. 60 would have been greatly reduced.

The injuries to persons aboard train No. 400 were caused by being propelled into seatbacks which collapsed and onto unpadded metal strips bordering the tops and sides of the seats. The Safety Board has discussed the injury-producing features of car interiors in previous reports. 1/ The Safety Board has made recommendations to the FRA regarding the unsafe design of these cars. Neither the FRA nor UMTA currently has any regulations for the interior design of passenger cars. Because of this lack of regulation, neither the FRA nor UMTA was involved with the design of the NJ DOT cars, even though their construction was funded by the Federal government. The Safety Board concludes that if the commuter cars on train No. 400 had been designed to eliminate injury-producing interior features, the number of injuries resulting from the collision would have been greatly reduced.

Emergency release mechanisms for doors and instructions for their operation should be clearly marked for use in case of derailment, collision, and fire. In this accident, the door operating instructions were locked inside the cabinet containing the operating device in the cars of train No. 400, and there was no sign on the cabinet to indicate the device was inside. The conductor of train No. 400 had not been trained to use the device. Amtrak and Conrail had not provided training and familiarization for railroad emergencies to local rescue organizations. The failure to provide identification of the emergency mechanism and Conrail's failure to train the crewmembers to use the device caused the removal of injured passengers to be delayed.

1/ "Railroad Accident Report--Derailment of a Richmond, Fredericksburg, and Potomac Passenger Train at Franconia, Virginia, January 27, 1970" (NTSB-RAR-71-1).

"Railroad Accident Report--Derailment of an Illinois Central Railroad Passenger Train near Salem, Illinois, June 10, 1971" (NTSB-RAR-72-5).

"Railroad Accident Report--Collision of Two Illinois Central Gulf Railroad Commuter Trains in Chicago, Illinois, October 30, 1972" (NTSB-RAR-73-5).

"Railroad Accident Report--Collision of Two Consolidated Railroad Corporation Commuter Trains in New Canaan, Connecticut, July 13, 1976" (NTSB-RAR-77-4).

Although the locked cabinet prevents misuse of the device during normal operations, the Safety Board believes that it is important to provide passengers a means of escaping from a car on their own without depending on crewmembers who may be disabled in an accident. While emergency windows permit escape, they are not as safe a means of egress as regular exit doors. Locks could be installed to prevent doors from being operated when power is applied.

Crewmember Training

On Amtrak's Northeast Corridor, Conrail employees operate Amtrak passenger trains, Conrail freight trains, and Conrail commuter trains. This division of responsibility creates a problem of insuring that crewmembers are properly qualified on the equipment to be operated. Amtrak accepts a Conrail employee as being qualified by the very act of reporting for an Amtrak assignment. In addition, Conrail does not monitor crewmembers for type of service on the Northeast Corridor because Conrail is not responsible for train operation. Because this investigation revealed that the engineer used the brakes improperly and the crewmembers lacked knowledge of emergency procedures, the Safety Board believes that Amtrak should accept responsibility for training and qualifying crewmembers who operate Amtrak passenger trains.

CONCLUSIONS

Findings

1. The engineer of train No. 60 had not been trained adequately to correct the mechanical problem that forced him to stop the train.

2. Interference on one of the train radio channels prevented the engineer of train No. 400 and the Landover operator from receiving the radio communication of the engineer of train No. 60 that said he was experiencing a mechanical problem and was stopping his train.

3. A design fault existed in the cab signal equipment on board train No. 400.

4. The cab signal could have possibly given a momentary display of an "approach" aspect on train 400.

5. The engineer of train No. 400 did not see train No. 60 at the point where it first became visible.

6. If the engineer of train No. 400 had properly applied the train brakes at the point where he was first able to see train No. 60, the train would have stopped short of the collision.

7. The engineer of train No. 400 improperly used the brake valve in attempting to stop his train.

8. The engineer of train No. 400 did not make an emergency brake application.

9. If the commuter cars on train No. 400 had been designed to eliminate injury-producing interior features, the number of injuries resulting from the collision would have been greatly reduced.

10. If the seats of the Amfleet cars had been maintained so that they properly locked in position, injuries on train No. 60 would have been greatly reduced.

11. The failure to provide identification of the emergency mechanism for opening the side doors and Conrail's failure to train the crewmembers to use the device caused the removal of injured passengers to be delayed.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 400 to perceive the train ahead and to properly apply the brakes in sufficient time to prevent a collision. Contributing to the accident was the failure of Amtrak to assure that the train crews were adequately trained. The causes of the large number of injuries in this relatively low-speed collision were the failure to maintain and service seats on the Amfleet equipment, and the injury-producing fixtures designed into the commuter cars.

RECOMMENDATIONS

During its investigation of this accident, the National Transportation Safety Board made the following recommendations:

-- to the Federal Railroad Administration on June 27, 1978:

"Use its emergency powers to require any carrier with locomotives and/or cars equipped with the General Railway Signal Company's cab signal systems to immediately establish instructions for the safe operation of trains so equipped until this equipment is repaired. (Class I, Urgent Action) (R-78-41)"

-- to the National Railroad Passenger Corporation (Amtrak) on June 23, 1978:

"Immediately arrange to have the defective cab signal systems corrected on these commuter cars and other locomotives using similar systems so that the systems will function as intended. (Class I, Urgent Action)(R-78-37)

"Until the cab signals are properly repaired, issue instructions for the safe operation of these trains. (Class I, Urgent Action)(R-78-38)

"Require all trains that operate on the northeast corridor to be equipped with an automatic train control system. (Class II, Priority Action)(R-78-39)

"Until an automatic train control system can be implemented on all trains, require that all 'stop and proceed' signals on the northeast corridor be regarded as 'stop and stay' signals by all trains equipped with locomotives and by self-propelled cars not equipped with automatic train control systems. If circumstances require such a train to enter an occupied signal block, the train dispatcher should be required to authorize the movement. (Class I, Urgent Action)(R-78-40)"

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

-- to the New Jersey Department of Transportation:

"Change the emergency release mechanism for the doors on all cars of the type involved in this accident so that the doors can be opened by passengers under emergency conditions, and properly identify the operating emergency equipment. (Class II, Priority Action)(R-79-29)

"Provide a means for emergency personnel to open car doors from the outside. (Class II, Priority Action)(R-79-30)

"Alter the interiors of the commuter cars to correct the injury-producing features of the car design. (Class II, Priority Action)(R-79-31)"

-- to the National Railroad Passenger Corporation (Amtrak):

"Restrict the NJ DOT commuter car from use on the Northeast Corridor until the interiors of the cars are altered to correct the injury-producing features of the car design. (Class II, Priority Action)(R-79-32)

"Accept the responsibility for training and qualifying train crewmembers operating trains over territory of the National Railroad Passenger Corporation. Require crewmembers operating on the mainline in passenger, freight, and commuter service to be certified by Amtrak as to types of service for which crewmembers are qualified. (Class II, Priority Action)(R-79-33)

"Establish train spacing so a following train will not be scheduled to operate on repetitive restrictive signals. Consideration should be given to departure time, train speeds, and station stops to avoid having following trains overtake and closely follow preceding trains. (Class II, Priority Action)(R-79-34)

"Arrange for a program along passenger train routes for training and familiarizing emergency rescue organizations in the type of train equipment being used. (Class II, Priority Action) (R-79-35)

"Establish a program to train crewmembers in the proper procedures for care of passengers in derailment and emergency situations. (Class II, Priority Action)(R-79-36)"

to the Federal Railroad Administration:

"Initiate a study of cab signal equipment that analyzes the relationship between noise levels in the traction motor return current and the filter characteristic of blocking, and its impact on the quality of the signal received by the cab signal equipment. (Class II, Priority Action)(R-79-37)

"Promulgate regulations to establish minimum standards for the design and construction of the interiors of passenger-carrying cars so that adequate crash-injury protection will be provided passengers. (Class II, Priority Action)(R-79-38)

"Promulgate regulations requiring that the emergency release mechanism for doors on passenger-carrying cars be clearly identified so that the doors can be opened easily by passengers in an emergency. (Class II, Priority Action) (R-79-39)

"Promulgate regulations establishing minimum standards for the training of traincrews in the safe operation of trains and in emergency procedures. (Class II, Priority Action) (R-79-40)"

The Safety Board also reiterates the following recommendations, which were made to the Federal Railroad Administration.

-- following the derailment of an Amtrak train at Pulaski, Tennessee on October 1, 1975:

"Require that Amtrak or the railroad operating an Amtrak train disseminate information to emergency units along the route on emergency entry techniques and on where emergency equipment within the car is located. (R-76-22)(issued July 5, 1976)"

-- following the collision of Penn Central Transportation Company-operated passenger trains Nos. 132, 944, and 939 near Wilmington, Delaware on October 17, 1975:

"Require carriers to train employees in emergency procedures to be used after an accident, to establish priorities for emergency action, and to conduct accident simulations to test the effectiveness of the program, inviting civic emergency personnel participation. (R-76-29)(issued July 30, 1976)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

March 8, 1979

APPENDIX A

PERSONNEL INFORMATION

H. V. Hoffmaster, Engineer, Train No. 400

Engineer Hoffmaster, 63, was employed by the Pennsylvania Railroad, predecessor to Conrail, on July 9, 1941. He was a locomotive fireman for 20 years and was promoted to Engineer in 1960; since then he has been operating locomotives as an engineer. On March 26, 1977, he was approved for duty by a carrier-approved doctor. He had received Air Brake Instructions on October 27, 1977, and was successfully examined on the Operating Book of Rules on December 27, 1977.

He qualified as an engineer by on-the-job training and he never received any formal classroom instruction for the position. For 6 years prior to May 1, 1978, he had operated older type self-propelled electric cars. Between May 1, 1978, and the date of this accident, he had operated the type of self-propelled electric car involved in the accident on 29 round trips for a total time of 20 hours 15 minutes. On May 1, 1978, a Conrail road foreman of engines rode with him on his first Baltimore-to-Washington trip with the new cars, for 1 hour 30 minutes, to familiarize the engineer with their operation. This was the extent of his instruction on the equipment.

F. D. Volz, Conductor, Train No. 400

Conductor Volz, 49, was employed by the Pennsylvania Railroad on July 7, 1951, as a freight brakeman. He transferred to passenger service on April 1, 1974, and qualified as a passenger conductor in August 1975. Since September 9, 1973, he has worked only Amtrak passenger trains or Conrail commuter trains. He had received Air Brake Instructions in December 1977, and was successfully examined on the Operating Book of Rules in April 1977. In May 1977, he was approved for duty by a carrier-approved doctor.

He received on-the-job training as a trainman and conductor. He had worked the commuter trains several times before the new cars were used. He had taken a hold-down assignment on the commuter train for June 7, 8, and 9, 1978. No familiarization instructions were given to him when he accepted this assignment.

K. B. Brandt, Flagman, Train No. 400

Flagman Brandt, 63, was employed by the Pennsylvania Railroad on March 23, 1942, as a trainman. He was promoted to conductor in 1945. For 6 years he has been on a regular assignment as ticket collector-flagman on the Baltimore-Washington commuter service. He received Air Brake Instructions on December 20, 1977, and was successfully examined on the Operating Book of Rules on December 1, 1977. On April 1, 1975, he was approved for duty by a carrier-approved doctor.

B. C. Schembs, Engineer, Train No. 60

Engineer Schembs, 28, was employed by Conrail on March 1, 1971, as a student fireman. On March 10, 1971, he was made a fireman. He worked 2 years as a locomotive fireman. In 1973, he entered Engineer's Training School. He received 6 weeks of classroom instruction in rules, safety, signals, and train handling theory. Since graduating from the school, he has worked as a locomotive engineer. His service as engineer has been predominantly in freight service with some infrequent extra passenger service. Train No. 60 was not his regular assignment.

M. DelNero, Conductor, Train No. 60

Conductor DelNero, 56, was employed by Conrail on January 15, 1943. He performed various duties in the transportation department and on March 22, 1966, was promoted to the position of conductor. He did not receive any formal training during his service but has gained his knowledge from on-the-job experience. He has worked in both passenger and freight service. Train No. 60 was not his regular assignment.

E. D. Karper, Fireman, Train No. 60

Fireman E. D. Karper, 22, was employed on October 9, 1974, by Conrail as a student fireman. He received 6 weeks of classroom instruction in rules, safety, signals, and train handling theory in the Conrail Engineer's Training School. He was promoted to engineer on June 24, 1977. All of his service has been in locomotive service, both passenger and freight. Train No. 60 was not his regular assignment.

M. R. Buettner, Trainman, Train No. 60

Trainman M. R. Buettner, 43, was employed on October 10, 1956, by Conrail as a trainman. He was promoted to conductor on March 21, 1960. All of his service has been in train service. Train No. 60 was not his regular assignment.

R. M. Geisendaffer, Trainman, Train No. 60

Trainman R. M. Geisendaffer, 56, was employed on July 11, 1951, by Conrail as a trainman. He was promoted to conductor on March 11, 1953. All of his service has been in train service. Train No. 60 was not his regular assignment.

T. P. Thomas, Trainman, Train No. 60

Trainman T. P. Thomas, 46, was employed on December 2, 1952, by Conrail as a trainman. He was promoted to conductor on March 3, 1935. All of his service has been in train service. Train No. 60 was his regular assignment.

L. G. Milburn, Trainman, Train No. 60

Trainman L. G. Milburn, 35, was employed on January 28, 1965, by Conrail as a trainman. He was promoted to conductor on September 14, 1966. All of his service has been in train service. Train No. 60 was his regular assignment.

A. L. Hartman, Trainman, Train No. 60

Trainman A. L. Hartman, 46, was employed on May 20, 1955, by Conrail as a trainman. He was promoted to conductor on January 14, 1965. All of his service has been in train service. Train No. 60 was not his regular assignment.

APPENDIX B

Excerpts from Conrail Rules for Conducting Transportation.

DEFINITIONS

INTERLOCKING

INTERLOCKING—An arrangement of signals and signal appliances so *interconnected that their movements* must succeed each other in proper sequence and for which interlocking rules are in effect It may be operated manually or automatically

SIGNALS

FIXED SIGNAL—A signal of fixed location indicating a condition affecting the movement of a train or engine

NOTE—The definition of a "Fixed Signal" covers such signals as switch target, train order, block, approach block limit, block limit, interlocking, speed signs, stop signs, yard limit signs, or other means for indicating a condition affecting the movement of a train or engine.

ASPECT—The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching train; the appearance of a cab signal conveying an indication as viewed by an observer in the cab

INDICATION—The information conveyed by the aspect of a signal

BLOCK SIGNAL—A fixed signal, or hand signal in the absence of a fixed signal, at the entrance of a block to govern trains and engines in entering and using that block

BLOCK LIMIT SIGNAL—A fixed signal indicating the limit of a block the use of which by trains or engines is prescribed by manual block signal system rules

CAB SIGNAL—A signal located in the engine control compartment or cab indicating a condition affecting the movement of a train and used in conjunction with interlocking signals and in conjunction with or in lieu of block signals

APPROACH SIGNAL—A fixed signal used in connection with one or more signals to govern the approach thereto

HOME SIGNAL—A fixed signal at the entrance to a route or block to govern trains or engines entering and using that route or block.

INTERLOCKING SIGNALS—The fixed signals of an interlocking

SPEEDS

NORMAL SPEED—The maximum authorized speed

LIMITED SPEED—Not exceeding 45 miles per hour

MEDIUM SPEED—Not exceeding 30 miles per hour

REDUCED SPEED—Prepared to stop short of train or obstruction

SLOW SPEED—Not exceeding 15 miles per hour.

RESTRICTED SPEED—Proceed prepared to stop short of train, obstruction, or switch not properly lined looking out for broken rail, not exceeding 15 miles per hour

NOTE—Speed applies to entire movement

BLOCK SIGNAL SYSTEMS

AUTOMATIC BLOCK SIGNAL SYSTEM (ABS)—A block signal system wherein the use of each block is governed by an automatic block signal, cab signal, or both

STATIONS

STATION—A place designated in the timetable by name

BLOCK STATION—A place provided for the blocking of trains by block signals or other means

BLOCK-LIMIT STATION—A place at which a block-limit signal is displayed

INTERLOCKING STATION—A place from which an interlocking is operated

BLOCK

BLOCK—A length of track of defined limits the use of which by trains and engines is governed by block signals, block-limit signals, cab signals or cab signals and block signals

ABSOLUTE BLOCK—A block in which a train or engine is not permitted to enter while it is occupied by another train or engine except as prescribed by the rules

551 The Cab Signal system is interconnected with the fixed signal system so that the Cab Signals will conform with the fixed signal indication within eight seconds after the engine passes fixed signal governing the entrance of the engine or train into the block in the direction for which the track and engine are equipped and engineman will be governed as follows:

(a) Cab Signals will not indicate conditions ahead when engine is:

(1) Moving against the current of traffic, except as provided in the timetable

(2) Pushing cars

(3) Not equipped with Cab Signal appara tus for backward movement and is run ing backward

(b) Cab Signal indication will not authorize operation of a train at speed higher than that authorized by the indication of the fixed signal that governed the movement of the train into a block, except when conditions affecting movement of trains in block change after passing signal

(c) When Cab Signal and fixed signal indications conform when entering the block and conditions affecting movement of train in the block change, the Cab Signal will govern

(d) When Cab Signal indication changes to Restricting, a train or engine must reduce speed at once not to exceed Restricted Speed

(e) When Cab Signal indication changes from Restricting to a more favorable indication speed must not be increased until train has run its length

(f) If a Cab Signal indication authorizes a speed different from that authorized by a fixed signal, when train enters the block governed by such fixed signal, the lower speed will govern The engineman will notify the Train Dispatcher or operator by radio, or by message as soon thereafter as will not cause delay to the train, giving location and track on which non-conformity occurred

If the Cab Signal authorizes a speed greater than the speed authorized by fixed signal, the engineman, in addition to notifying the Train Dispatcher, will also verbally advise the enginehouse foreman or his representative on arrival at engine terminal so that the engine may be withheld from service and equipment not be disturbed

(g) When Cab Signal indication "flips' (indication changing to more restrictive momentarily), engineman, as soon thereafter as will not cause delay to train, will file a message reporting the occurrence to Train Dispatcher in following manner:

Cab Signal flipped on No ——— track (state indication), to (state indication) at signal bridge or MP No ——— and state whether they were acknowledged

(h) The Cab Signal apparatus will be considered as having failed when:

(1) The warning whistle fails to sound when the Cab Signal changes to a more restrictive indication, or it continues to sound after being acknowledged

(2) The Cab Signal aspect fails to conform at two fixed signal locations in succession

When Cab Signal apparatus has failed, the train will proceed governed by Rule 554 and a report must be made to Train Dispatcher or operator by radio, or if not so equipped, at first point of communication where stop can be made without excessive delay The warning whistle may be cut out only if it continues sounding after being acknowledged

(i) If the Cab Signal warning whistle sounds longer than six seconds the member of crew nearest the operating compartment of the engine will go to the engineman immediately

Rule 285

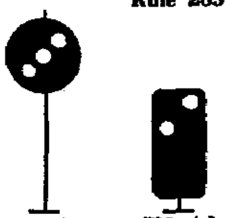


FIG A FIG. A-1

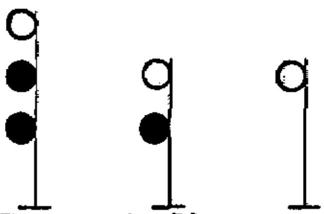


FIG. B FIG. B-1 FIG B 2

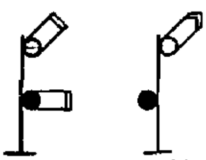


FIG C FIG. C-1

IN CAB SIGNAL TERRITORY
CAB SIGNAL WILL DISPLAY

INDICATION—Proceed prepared to stop at next signal. Train exceeding Medium speed must at once reduce to that speed.

NAME: Approach.

Rule 291

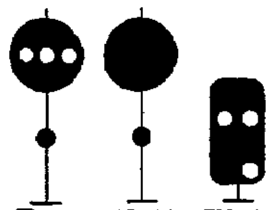


FIG. A FIG. AA FIG. A-1

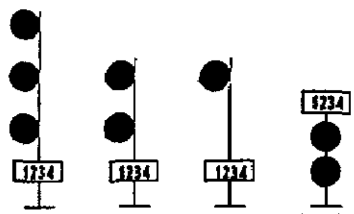


FIG. B FIG. B-1 FIG. B-2 FIG. B-3

FIG. C

IN CAB SIGNAL TERRITORY
CAB SIGNAL WILL DISPLAY

AND FIXED SIGNAL INDICATION WILL GOVERN

INDICATION—Stop; then proceed at Restricted speed

NAME: Stop and proceed.

NOTE—Where, in addition to the number plate, a letter G, grade marker, is displayed as part of these aspects, Rule 290 applies.

APPENDIX C

Excerpts from report of Amtrak's Communication & Signal - Electric Traction Engineer.

INCIDENT INVOLVING TRAINS 400 AND 60 AT SEABROOK, MD. JUNE 9, 1978

OVERVIEW CAB SIGNALS

There are three separate issues concerning cab signals which arise out of the rear end collision of train 400 overtaking and colliding with train 90:

a. Behavior of the cab signal of car 590 as involved in the rear end collision.

b. Problems associated with design of cab signal equipment that developed as an outgrowth of intensified investigation of the Seabrook incident.

c. Further investigation of noise from controlled rectifier equipped vehicles in traction return path.

SITUATION:

The engineman of train 400 had indicated that his cab signal had gone from restricting to approach north of the Beltway Station after he had passed a Stop and Proceed wayside signal at 128R.

CONCLUSIONS:

In an intense examination and testing of the cab signal equipment of cars 590-591 an inherent design problem has been unearthed which causes the cab signal equipment to sustain an approach or approach medium aspect when coded 100 hertz energy in the rails is changed to steady low level 100 Hertz energy in the rails.

In the incident at Seabrook, the necessary electrical parameters in the wayside environment do not exist to have sustained the "Approach" aspect in the cab signal equipment (to include considerations of the design failure).

Even though not reproduced subsequent to the accident, the mechanics existed to have possibly given the engineman a short flip to approach in the area north of 128L signal to a point approximately 3890 feet ± north thereof, to a track rail joint with a broken rail bond; but the mechanics to have held it at Approach did not exist.

The front end filter for cab signal input is designed to include a pair of current limiting diodes designated CR2 and CR3 which appear to behave like a varactor, and reflecting into the 100 Hertz filter, with overload, appear to produce a strong third harmonic of the traction return energy. This does not constitute a "clear failure mode" in itself; but appears to add to the mechanics of "blockage" of the front end with noisy traction unbalance, a subject which requires further study.

The testing at Frazer substantiates the relationship between noise levels in the traction return and the source impedance wherein the amplitude of extraneous frequencies developed by the traction return of rectifier type vehicles is a function of the source impedance. This impacts certain earlier papers in the public domain which are unduly optimistic in their conclusions; but premised upon measurements taken against soft sources.

The traction return situation has been under close examination with certain testing having been accomplished prior to Seabrook; but completion of data collection depending upon certain Electric Traction Conversions at the test site. This is a continuing program which does have an impact on quality of signal received by cab signal equipment.

TEST SUMMARY:

From prior emperical testing procedures, we have determined under very unique conditions of traction return noise and pulsing of traction return we have been able to produce an approach cab signal aspect as a short flip employing cars or locomotives which have a controlled rectifier traction return. It is this mode, giving the incident its due, that we were looking for at Seabrook, on basis of introduction of noise into the cab signal system as a consequence of any unbalance traction return caused by the existance of a bond being broken around a bolted joint in welded rail territory. Since the joint was recognized as being tight, testing was done with extreme unbalance and also with joints partly shunted with resistors.

The mechanics of code was considered as the jog of the car controller, necessary on the part of the engineman in operating at a very slow speed. The internal controls of the car place time against application of power (to prevent flashover of commutators, etc.) and to more closely match a seventy five code rate, the time delay mechanisms were set back on the cars. There was inadequate speed involved to consider pantograph bounce a cause of interruption to traction return.

Because of traffic congestion, these tests were operated at both the Seabrook site as well as on the Main Line Harrisburg.

These tests, with the exception of one wink (L Relay getting off its back contact), were unconclusive in respect to the claimed "approach". We have no feedback, at this time, as to the tests on the Bulb filaments of the cab signal indicator in the attempt to determine which lamps were illuminated at moment of impact, these lamps having been turned over to the NTSB for study.

The cars were detail tested to determine the integrity of wiring and operation (fortunately the cab signal equipment was in the second car #591, of the cuplett), and it was at this point the cab signal apparatus demonstrated an ability to sustain oscillations. After determination of the external parameters, an investigation was made to determine if it was a random equipment failure, or a design oversight. Suspecting the latter we placed our management on notice to restrict the entire fleet of GRS Cab Signal equipment which was subsequently accomplished upon determination that we indeed had a design oversight. The mechanics of the failure, call for a narrow margin of specific electrical wayside parameters not involved at Seabrook with its universal coded track circuits where the incident took place; but a possible exposure elsewhere in interlockings, for example; therefore the need to continue quarantine in accepting approved aspects. The failure mode upon further analysis and testing resulted from ringing energy from decoder tank circuits triggering the flip flop output of amplifier.

In the desire to further investigate the mechanics of the front end, to determine if the noise even from cars own accessories would overwhelm the front end filter, we established a single rail track return over a wire loop test rack. The results of this testing with 27 amperes of track return current exclusively from accessories under a single rail prevented the flip flop from functioning on 1.7 Amps of loop current. The interesting point developed here was that the front end was demonstrated as being "blocked" (as proven by subsequent need for raising of loop current to 3.8 amps to again recover), rather than the noise filling in the off time of code as a possible failure mode. The 3.8 Amps 100 Hertz loop current, at site of single rail traction return was marginal on the low side and therefore we were again able to force sustained oscillation of the cab signal equipment. During this test series, as was done in other instances, as a control reference the loop response was proven as being normal, with both rails bonded and cross tied beyond ends of loop.

The filter characteristic of blocking was noted in scope displays while making runs under controlled conditions. All runs were made with and without instrumentation connected; particularly as the self oscillation mode was noted as being so critical that it was lost in the circuit loading of instrumentation.

As examples of noise, attached are extracts of voltages to ground taken at the rail as the train approached in various modes.

Also attached are certain frequency plots of inputs to filter and amplifier developed from recordings made from the various test runs on a Honeywell multi-channel frequency modulated recorder.

More work is being done in these areas giving the benefit of our results to the manufacturer.

BF/bb
Attachments

Belknap Freeman

Belknap Freeman, P.E.
Communications & Signal - Electric
Traction Engineer
Northeast Corridor, Amtrak
Philadelphia, Pa.
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