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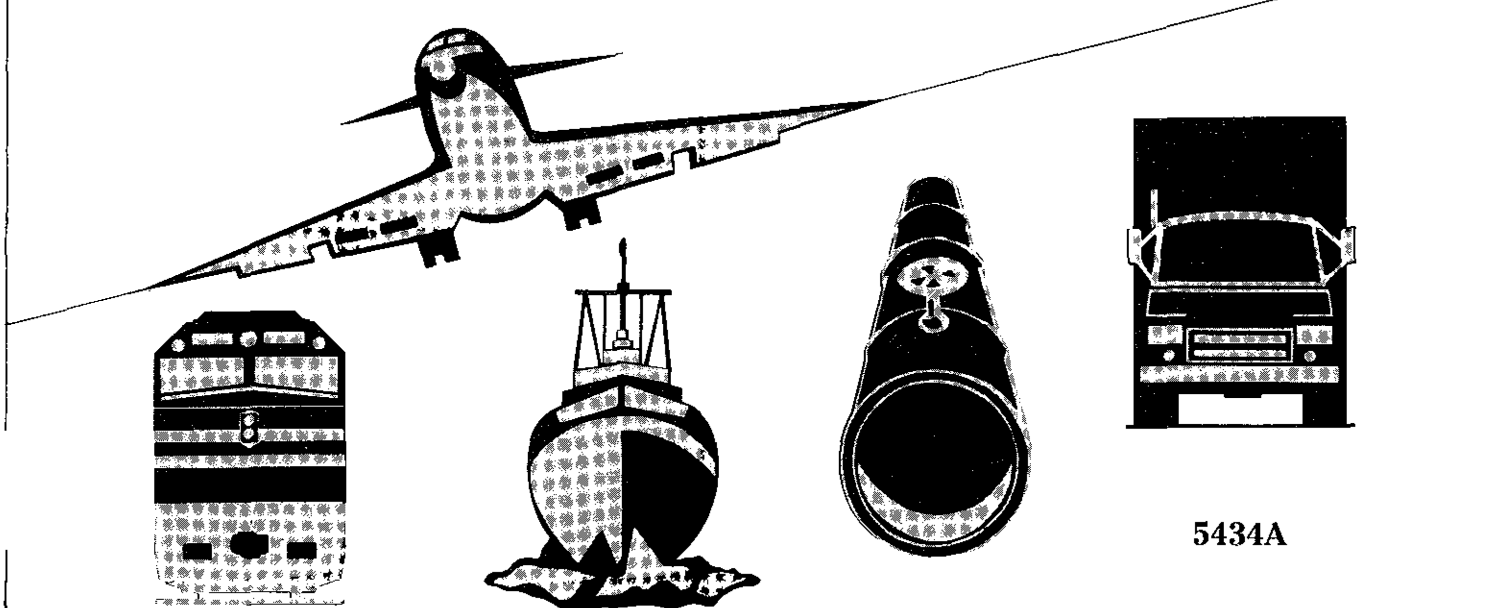
...IONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT AND COLLISION OF AMTRAK PASSENGER TRAIN 66 WITH MBTA COMMUTER TRAIN 906 AT BACK BAY STATION BOSTON, MASSACHUSETTS DECEMBER 12, 1990



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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

ADOPTED: FEBRUARY 25, 1992

NOTATION 5434A

Abstract: At 8 23 a m on December 12, 1990, National Railroad Passenger Corporation (Amtrak) passenger train 66, consisting of a two-unit locomotive, two material handling cars, five passenger cars, one dining car, and two baggage cars, derailed and struck Massachusetts Bay Transit Authority (MBTA) commuter train 906, consisting of one locomotive, six passenger cars, and one control car, as both trains entered Back Bay station in Boston, Massachusetts

In this report the following safety issues are discussed: train operations and speed limits, locomotive engineer training and Federal Railroad Administration certification, and locomotive event recorder data

As a result of its investigation, the Safety Board made recommendations addressing these issues to the National Railroad Passenger Corporation, the Federal Railroad Administration, the Brotherhood of Locomotive Engineers, and the United Transportation Union

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EXECUTIVE SUMMARY

At 8:23 a.m. on December 12, 1990, National Railroad Passenger Corporation (Amtrak) passenger train 66, consisting of a two-unit locomotive, two material handling cars, five passenger cars, one dining car, and two baggage cars, derailed and struck Massachusetts Bay Transit Authority (MBTA) commuter train 906, consisting of one locomotive, six passenger cars, and one control car, as both trains entered Back Bay station in Boston, Massachusetts

Operated by an apprentice engineer, Amtrak train 66 was traveling 76 mph, within a 30-mph speed restriction, on a 9° 30' curve when it derailed and struck MBTA train 906 on the adjacent track A fire ignited after the collision On Amtrak train 66, 7 crewmembers and 43 passengers sustained injuries, on MBTA train 906, 5 crewmembers and 391 passengers were injured, and 7 firefighters sustained injuries Estimated damage exceeded $12 5 million

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the apprentice locomotive engineer to reduce speed in sufficient time to negotiate the curve into Back Bay station as a result of inadequate supervision provided by the locomotive engineer. Contributing to the accident was Amtrak's failure to provide adequate quality control oversight for its locomotive engineer training program, including the adequacy of selection and training for apprentices and selection and training of engineers who serve as supervisors to apprentices during on-the-job training Also contributing to the accident was Amtrak's failure to have advance warning devices for a speed reduction for the curve entering Back Bay station

The safety issues discussed in this report are:

- train operations and speed limits,
- locomotive engineer training and Federal Railroad Administration certification, and
- locomotive event recorder data

As a result of its investigation, the Safety Board made recommendations addressing these issues to the National Railroad Passenger Corporation, the Federal Railroad Administration, the Brotherhood of Locomotive Engineers, and the United Transportation Union

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT AND COLLISION OF AMTRAK PASSENGER TRAIN 66 WITH MBTA COMMUTER TRAIN 906 AT BACK BAY STATION BOSTON, MASSACHUSETTS DECEMBER 12, 1990

INVESTIGATION

The Accident

At 10:30 p m on December 11, 1990, National Railroad Passenger Corporation (Amtrak) passenger train 66 departed Washington, D C , for Boston, Massachusetts The operating crew changed at New York City, New York, and again at New Haven, Connecticut The New Haven to Boston operating crew, comprising a locomotive engineer, an apprentice engineer, a conductor, and two assistant conductors, reported for duty at 4:30 a m on December 12, 1990, at the New Haven station (mile post[1] [MP] 72 3) on Amtrak's Boston division As part of Amtrak's locomotive engineer training program, the apprentice engineer had been assigned to the crew

Between Washington and New Haven, electric locomotives had powered Amtrak train 66 These electric locomotives were removed and replaced with a diesel-electric, two-unit F40PH locomotive (272 and 366), from the New Haven motor storage area

The locomotive crew received a list of speed restrictions for their trip and then performed a ground (walkaround) inspection They boarded the two-unit locomotive at 4:36 a m , reviewed the cab defect and inspection cards, and checked the radio They also did an airbrake test, applying and releasing the locomotive brakes The crew noted no exceptions to the condition of the locomotive The locomotive engineer then assigned the apprentice engineer to operate the locomotive, and the apprentice engineer did so, under the direct supervision of the locomotive engineer, for the entire trip

With the front of both units headed eastward, the locomotive moved from the motor storage area to the passenger station and was coupled to the 10-car passenger train A car inspector assisted in the coupling procedure and made the necessary air hose connections between the locomotive and the east (first) car of the train From the rear of the train, the car inspector made an airbrake test The apprentice engineer applied the automatic brake valve to set and then release the train airbrakes The car inspector made a ground inspection of the train, observed that the airbrakes were released, and then released the train for departure At 5:25 a m Amtrak train 66 left New Haven on schedule

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[1]A point used for location identification, not for distance measurement

Shortly after leaving New Haven, the event recorder data registered a moving airbrake test The apprentice engineer stated that the brake system functioned properly According to the Amtrak dispatcher's office train performance records, the train continued on schedule and the crew operated in compliance with the speed limit, until two unscheduled station stops at Groton, Connecticut, and South Attleboro, Massachusetts The Amtrak timetable showed the maximum authorized speed for Amtrak train 66 as 100 mph. The event recorder data registered that Amtrak train 66 operated at speeds up to 110 mph between Kingston and Providence and between South Attleboro and Route 128. (See figure 1.)

Amtrak train 66 made its regular station stops at Old Saybrook, New London, Mystic, Westerly, Kingston, and Providence According to the locomotive engineer, he moved from the fireman's seat on the left side of the locomotive to a position behind the apprentice engineer to supervise and instruct him in the proper brake application at each station stop. The locomotive engineer added that the method of operation he used when instructing an apprentice engineer was to "talk" that apprentice engineer through every station. Both engineers reported that all stops were normal and noted no exceptions to the handling of the train en route. The locomotive engineer stated that he cautioned the apprentice engineer about applying the brakes and slowing early for the stop at Westerly and then accelerating too fast on departing Kingston

Both engineers and the conductor described the trip as normal except for a radio report from the operator at Groton tower (MP 124 2) that a door was open on baggage car 1217, which was the second car behind the locomotive The locomotive engineer advised the apprentice engineer to stop on straight track east of Groton near MP 127 The conductor and an assistant conductor closed the door on car 1217 After a 6-minute delay, Amtrak train 66 resumed its eastbound trip

According to the Amtrak dispatcher's office train performance records, Amtrak train 66 was 6 minutes late at Mystic (MP 131 90) but was on schedule at Atwells (MP 184.2) The dispatcher notified the traincrew to stop at South Attleboro (MP 192) to board passengers. The stop at South Attleboro required about 4 minutes Amtrak train 66 made its regular station stop at Route 128 (MP 217 3) on schedule (For stopping information, see figure 1)

After departing Route 128, the apprentice engineer noticed that a continuous air-blowing sound had developed near the automatic airbrake valve He reported this sound to the locomotive engineer, who immediately moved to a position behind the apprentice engineer The locomotive engineer described the sound as a hissing and said that it happens frequently, adding, "Apparently it's a little piece of dirt in the brake valve that clears itself, usually no big deal " The locomotive engineer stated that he used the automatic airbrake valve to make an application and release of the brakes, and the air-blowing sound stopped The apprentice engineer said that when the air-blowing sound began again, he made a set and release of the automatic airbrake valve, and the sound again stopped. Event recorder data did not show these brake valve movements

In preparation for the stop at Back Bay station (MP 227 6), the locomotive engineer said that he advised the apprentice engineer to begin applying the automatic airbrakes when the Ruggles Street station (MP 226 5) platform came into view According to the apprentice engineer, while the train operated at 94 mph

TRAIN 66 PERFORMANCE
DECEMBER 12, 1990

STATION	MILEPOST	TIME	PERF	DELAY:
New Haven	72 3	5:25 A	O T	
Fair St	72 7	5:27 A	+1	
Branford	81 5	5:37 A	+3	
Old Saybrook	105 1	5:59 A	O T	
Conn	106 8	6:01 A	+2	
Nan	116 7	6:10 A	+2	
Groton	124 2	6:24 A	+2	
Mystic	131 9	6:40 A	6 →	[6' MP 127 Close Baggage Door Fireman's Side 1217]
Cranston	181 2	7:24 A	+3	
Atwells	184 2	7:28 A	O T	
Orms	185 6	7:42 A		
Attleboro	197 0	7:56 A	4 →	[4' - Station stop So Attleboro A/C No 808 Late]
Jct	213 9	8:09 A	1	
Transfer	218 5	8:16		
Read	219 6	8:17	+1	
Forest	223 5	8:20 A	+2	
Plains	224 3	8:20 A	+2	

TIMETABLE No 3
In effect 12 01 A M , Eastern Standard Time
Sunday, October 28, 1990

STATION	Mile Post	Daily (A M)
New Haven	72 3	5 26
Old Saybrook	105 1	5 59
New London	122 9	6 21
Mystic	132 3	6 36
Westerly	141 3	6 48
Kingston	158 1	7 06
Providence	185 1	7 40
Route 128	217 3	8 14
Back Bay	227 6	8 30
Boston (South Station)	228 7	8 35

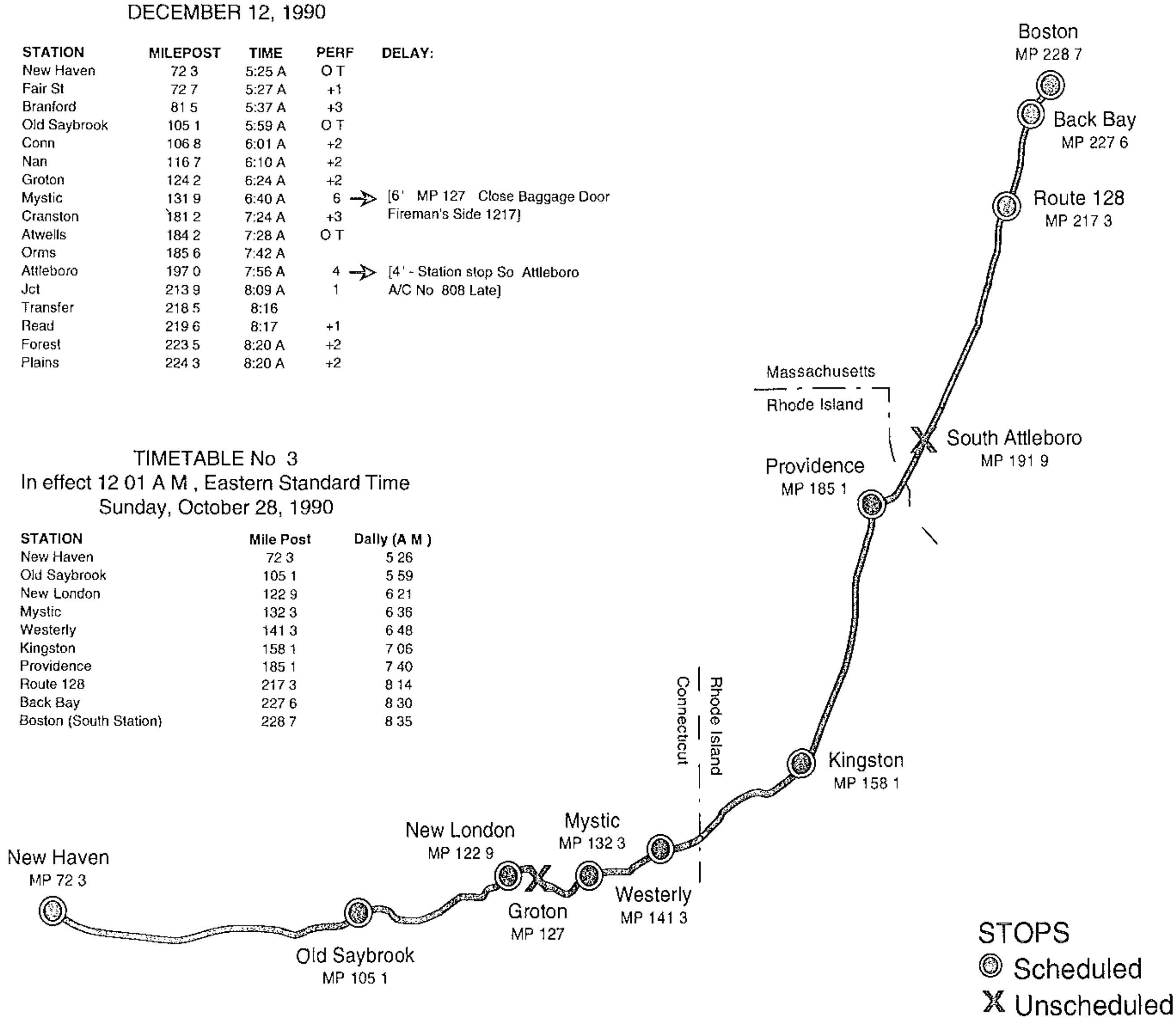

Figure 1.--Amtrak train 66 route between New Haven and Boston,with train performance record and timetable schedule

with the throttle in run 4 or 5 position, [2] he made a minimum 10- or 12-pounds per square inch (psi) service application of the automatic airbrakes shortly before passing the eastbound wayside automatic block signal (MP 226 2) west of Ruggles Street station (See figure 2) He stated that he then released the locomotive independent brake and reduced the throttle to run 1 or 2 position The locomotive engineer said that the brakes did not exhibit the normal reaction and that the train slowed only a little when it should have slowed more

The locomotive engineer instructed the apprentice engineer to make a further brake application, and the apprentice engineer made a 32-psi full-service application while passing the Ruggles Street station platform The locomotive engineer stated that they could sense that the train was not slowing down sufficiently According to the apprentice engineer, the locomotive engineer made an emergency application of the automatic airbrakes. The train moved eastward into the tunnel at MP 227 on track 2 and entered the 9o 30' right curve near MP 227 4, 200 feet from the point of derailment (POD) The locomotive engineer said that the train entered this curve "hard " Neither the locomotive engineer nor the apprentice engineer noticed the train speed at that time. The speed restriction on all tracks (1, 2, and 3) through Back Bay station from MP 227 to MP 228 3 is 30 mph (See figure 2)

On board Amtrak train 66, neither the conductor, two assistant conductors, nor a deadhead conductor (a railroad employee traveling to a work assignment) heard an application of the airbrakes before the accident. The train 66 conductor felt the brakes apply on the train. The other crewmembers were able to state only that the train was slowing for the Back Bay station

As Amtrak train 66 moved into the curve, the locomotive crew felt the locomotive tip to the left toward track 1 As Amtrak train 66 approached the west end of the Back Bay station platform, its locomotive crew saw locomotive 1073 of the Massachusetts Bay Transit Authority (MBTA) commuter train 906 on track 1 The locomotive crew reported that events then became unclear until after the collision with the MBTA train 906 (See figure 3)

Shortly before 7 45 a m , the MBTA train 906, comprising one control car, six coaches, and one locomotive, had departed Stoughton, Massachusetts, eastbound for South Station, Boston The MBTA train 906 was a push/pull operation; the locomotive was on the rear (west end) of the train in the pushing mode The MBTA train 906 operated with an Amtrak crew comprising a conductor, three assistant conductors, and a locomotive engineer The locomotive engineer was operating the train from the control car cab, which was equipped with locomotive controls, at the front (east end) of the train. The locomotive engineer stated that the MBTA train 906 was almost stopped on track 1, moving about 5 to 10 mph, at the time of the accident He was standing at the controls in the cab, felt the collision, and was knocked to the floor Not knowing exactly what had happened, he made an emergency radio call to the dispatcher.

At 8 23 a.m in the Boston train dispatcher's office, the Centralized Electrical and Traffic Control (CETC) system illuminated a "track occupied" light (TOL) for track 3 at Back Bay station. The dispatcher stated that before the TOL illuminated,

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[2]A locomotive throttle has eight power positions

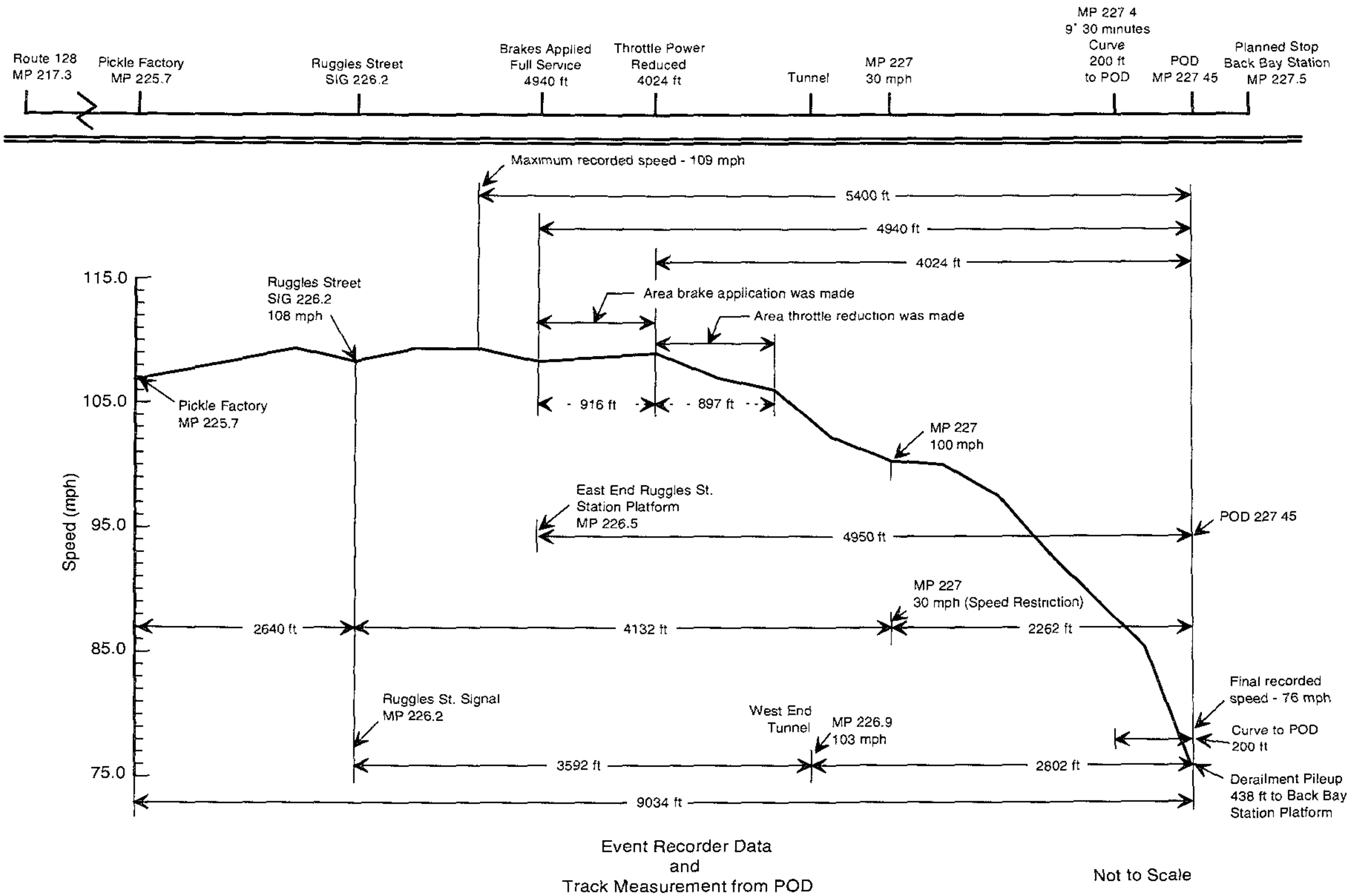

Figure 2 --Diagram of Amtrak train 66 speed and distance travelled.

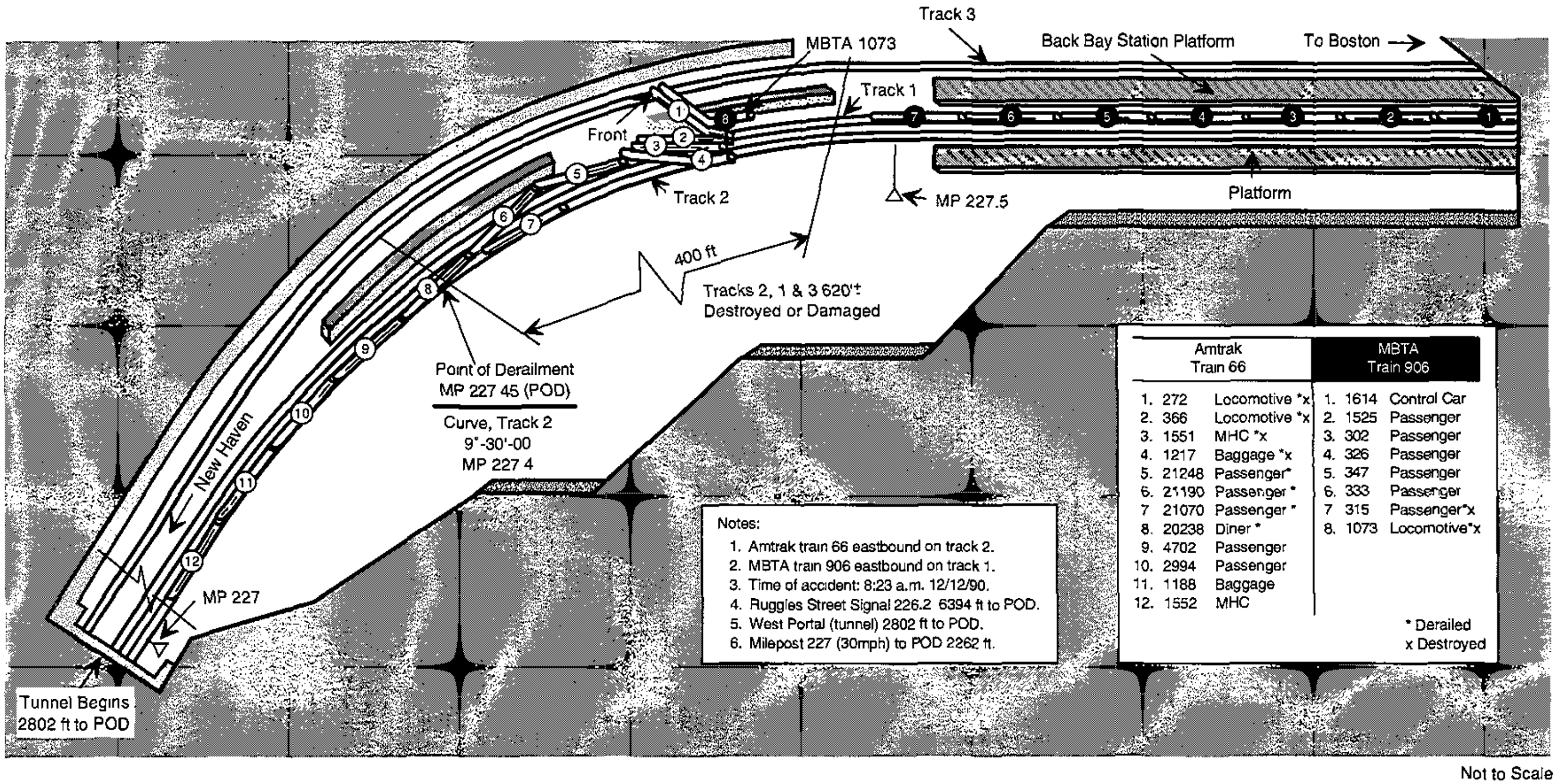

Figure 3 --Diagram of derailment site.

track 3 had been clear and no trains had been routed for it. The derailed train equipment had fouled track 3 Shortly after noticing the TOL, the dispatcher heard the Mayday radio transmission from the locomotive engineer of MBTA train 906 advising of an emergency at Back Bay station and to hold all trains The dispatcher heard no conversation from the crew of Amtrak train 66 and was unable to contact them on the radio

At 8:24 a m., from the Back Bay station platform, a passenger from MBTA train 906 telephoned the 911 operator for the Boston Emergency Medical Service (EMS). The first EMS units arrived at 8·28 a m The EMS personnel and both traincrews began evacuating the injured passengers and injured crewmembers After the accident, the conductor of MBTA train 906 described the evacuation as orderly The EMS transported 278 people with injuries to local hospitals Among the 14 admitted were the locomotive engineer and apprentice engineer from Amtrak train 66 and 7 firefighters. No fatalities occurred as a result of the accident.

Both trains sustained massive equipment damage The fuel tank on Amtrak locomotive 366 broke loose, and a diesel fuel fire ensued The fire department quickly extinguished the fire, but moderately heavy smoke and minor fire damage resulted Exhaust fans in the tunnel reduced the smoke and removed it completely after the fire was extinguished

Injuries

Injuries	Amtrak Train 66 Crew	Amtrak Train 66 Passengers	MBTA Train 906 Crew	MBTA Train 906 Passengers	Other	Total
Fatal	0	0	0	0	0	0
Serious	2	3	0	3	6	14
Minor	5	40	5	388	1	439*
None	0	147	0	509	0	656
Total	7	190	5	900	7	1,109

*After the accident, an additional 175 passengers reported injuries

Damages

On Amtrak train 66, the two-unit locomotive and five cars were destroyed, and one car was significantly damaged On MBTA train 906, the locomotive and one car were destroyed

Tunnel structure damage required the replacement of two concrete support columns, six bridge girders, and bridge decking, the resurfacing of Dartmouth Street; and repairs to the support column wall and utilities Signal cable damage was minor

Amtrak and the MBTA estimated the damages as follows:

Locomotives and equipment	$9,235,000
Track and signal	322,325
Tunnel and street	2,877,675
Clearing	240,000
Total	$12,675,000

Crew Information

MBTA Train 906 --Before reporting for duty at 4:10 a.m. on December 12, the crew had been off duty for more than 8 hours and were rested in accordance with the Hours of Service Act. The crew was qualified by Amtrak for their respective positions and had attended an operating rules and instructions class in the previous 12 months.

Amtrak Train 66.--Before reporting for duty at 4:30 a m on December 12, the crew had been off duty for more than 8 hours and were rested in accordance with the Hours of Service Act The crew was qualified by Amtrak for their respective positions and had attended an operating rules and instructions class in the previous 12 months

The locomotive engineer of Amtrak train 66 had been hired by the New York, New Haven and Hartford Railroad (NYNH&H) in August 1957 The Penn Central Railroad, which had acquired the NYNH&H in January 1969, promoted him to locomotive engineer in October 1969 He had been operating in the same territory (now part of the northeast corridor) his entire career In February 1976, he served as a Penn Central classroom instructor who demonstrated the operation of locomotive equipment.

In September 1976, Amtrak employed him as a road foreman In this supervisory position, he trained and qualified locomotive engineers for passenger service On January 16, 1979, while moving locomotives, he was distracted when talking to a traincrew and proceeded past a stop signal at Pelham Bay, New York Amtrak dismissed him as a road foreman He then exercised his seniority rights, returned to Conrail as a locomotive engineer, and operated Amtrak passenger trains under contract to Conrail When Amtrak hired its own locomotive engineers in January 1983, he transferred to Amtrak

On March 9, 1990, the Metro-North Commuter Railroad banned the locomotive engineer for life from operating on its trackage (New Haven to New Rochelle, New York), except New Haven terminal, for noncompliance with operating rules While resetting a relay switch in the locomotive, he had passed a stop sign. In addition to the ban, the locomotive engineer was suspended and held off duty without pay for 30 days by Amtrak

On April 9, 1990, the locomotive engineer returned to Amtrak service as a locomotive engineer on the Boston division, operating trains from New Haven to Boston He had been working Amtrak train 66 on regular assignment since the end of October 1990 His regular schedule was Tuesday through Saturday, with Sunday and Monday off. On Monday, December 10, 1990, the locomotive engineer, who lives alone in New Haven, had no special activities On Tuesday, December 11, he deadheaded to Boston on Amtrak train 66 to meet his regular assignment on Amtrak train 153 from Boston, departing 11:15 a.m , to New Haven, arriving 1:36 p.m He went home and rested, remaining off duty for more than 14 hours 54 minutes. On Wednesday, he reported for duty on Amtrak train 66 about 4 30 a.m.

In July 1973, Amtrak hired the apprentice engineer as a ticket clerk, and in August 1987, he transferred to a position as engine attendant at New Haven He entered Amtrak's locomotive engineer training program on June 11, 1990, and made regular physical characteristic training trips over the road, until

September 13, 1990 From June 11 to July 9, 1990, he observed between New Rochelle and Harold, New York, from July 10 until August 8, between New Haven and Penn Station, New York; and from August 13 to September 13, between New Haven and Boston On September 17, 1990, he entered Amtrak's engineer training school, which he completed on November 9, 1990 He took 16 tests in the school on which his grades ranged from 75 to 100 percent, except in train handling/operations, on which he scored 55 percent. At the end of the formal classroom training in the school, he was sent to the locomotive simulator facility at the Illinois Institute of Technology (IIT), Chicago, Illinois, where he received passenger train operation training His simulator operating scores at the end of this training were 100 percent for rules compliance, 78.56 percent for train handling technique, and 30 percent for train handling efficiency

After a 4-week vacation, the apprentice engineer returned to the training program. On December 10 and 11, he completed two round trips as part of the on-the-job training (OJT) phase of train operations. About noon on Monday, December 10, he reported to New Haven for his first OJT trip on Amtrak train 168, which arrived in Boston about 2:25 p m , he returned to New Haven on Amtrak train 193, arriving about 9 p m About 4:30 a m on Tuesday, he reported to New Haven for his second OJT on Amtrak train 66, which arrived in Boston about 8 30 a m ; he returned to New Haven on Amtrak train 153, arriving about 1 30 p m He went home and rested, remaining off duty for 14 hours 15 minutes before reporting back for duty About 4·15 a.m on Wednesday, the apprentice engineer reported for his third OJT on Amtrak train 66 This trip was the third one on which the apprentice engineer operated the locomotive into Back Bay station and the first time he operated into Back Bay station from New Haven to Boston with this engineer The engineer and apprentice had been acquainted for over 15 years

Train Information

MBTA Train 906 --The MBTA commuter train 906 comprised one control car (1614), six passenger cars (1525, 302, 326, 347, 333, and 315), and one locomotive (1073)

MBTA train 906 was configured for push/pull service, which allows trains to make round trips without repositioning the locomotive unit A locomotive is at one end and a control car is at the other end of the consist The locomotive provides the power, which the locomotive engineer controls either directly from the locomotive or remotely from the control car When the locomotive engineer operates from the control car, the train is in the push mode, when he operates from the locomotive, the train is in the pull mode At the time of the accident, MBTA train 906 was in the push mode

Amtrak Train 66.--Amtrak train 66 comprised a two-unit diesel-electric locomotive (272 and 366), a material handling car (1551), a baggage car (1217), three passenger cars (21248, 21190, 21070), a dining car (20238), two passenger cars (4702 and 2994), a baggage car (1188), and a material handling car (1552).

Manufactured by the Electro-Motive Division of General Motors Corporation, each locomotive unit was a four-axle, 3,000-horsepower, model F40PH with an 1,800-gallon diesel fuel tank At the time of the accident, each one carried about 1,500 gallons of diesel fuel According to the design data calculations, F40PH locomotive units carrying 1,500 gallons of fuel have a turnover speed of about 59 mph in a 9° 30' curve They were equipped with blended dynamic brakes, automatic airbrakes, locomotive independent brakes, and continuous cab signals that had speed control, event recorders or speed tapes, and radios

Tunnel, Signal, and Track Information

Tunnel --At the west end of the Back Bay station platform, the tunnel is approximately 86 feet wide The derailment occurred at MP 227.45, where the tunnel is approximately 62 feet wide in a 9° 30' curve The three main tracks (1, 2, and 3) run south to north Between tracks 1 and 3, a 3-foot thick, 8 1/2-foot high concrete crash wall with support columns restricted the width of the tunnel for tracks 1 and 2 to approximately 36 feet The passenger loading platforms are between tracks 1 and 3 and on the south side of track 2

Signals --The automatic block and control signal indications from the CETC system in the Boston train dispatcher's office govern train movements through Back Bay station Control for train movement on main tracks is by signal indication, which operates trains in both directions using wayside automatic block and locomotive cab signals

The automatic speed control system, which functions in signalized territory, is connected to the locomotive cab signal, it is independent of and not connected to the locomotive's speedometer and event recorder. If the locomotive engineer fails to reduce speed to the authorized level in cab signal territory, the speed control automatically triggers a brake application to slow and stop the train Signal 226 2 at Ruggles Street was not coded to provide the 30-mph speed restriction at MP 227

Before the accident, the train dispatcher had routed Amtrak train 66 on track 2 for "clear, proceed" signals The locomotive crew on Amtrak train 66 stated that both the locomotive cab signal and the wayside automatic block signal at MP 226.2 displayed "clear, proceed" aspects, indicating a clear track ahead and authorizing Amtrak train 66 to proceed at the maximum track speed of 100 mph The train was authorized to operate at that speed until MP 227, where the speed restriction is 30 mph and remains in effect until MP 228 3 At the approach to the 30-mph speed restriction at MP 227, no speed signs were posted to warn of the restricted speed ahead

Track --Built in 1987, the track is 132-pound continuous welded rail with 24-inch centered concrete crossties It is ballasted to the concrete tunnel floor with 24-inch deep crushed rock Near the POD, the north rail is fitted with an operative wheel-flange lubricator about 750 feet west of the curve

The MBTA owns the track, and Amtrak maintains it for trains operating at speeds up to 100 mph Amtrak performs scheduled track inspections twice weekly, at intervals of at least 1 day, and does daily walking inspections of concrete ties In May 1990, the Federal Railroad Administration (FRA) had inspected the track and noted no defects in the derailment area An ultrasonic internal rail defect inspection of track 2 on October 20, 1990, also revealed no defects in the derailment area On December 11, 1990, Amtrak conducted the last track inspection before the accident and found no defects in the derailment area

Postaccident Track Examination --The POD was at MP 227 45 on track 2 Derailment marks on track 2 were approximately 2,262 feet past MP 227 inside the west portal of the tunnel and approximately 438 feet from the station platform The initial derailment marks were on the north end of three crossties, approximately 14 feet east of the transition point from straight to curve on track 2

At the initial derailment marks on track 2, both rails remained undisturbed on the ties Beginning 250 feet before the POD, the track was forced approximately 1 inch out of alignment for 62 feet to the south The track immediately east of the POD was heavily damaged for approximately 30 feet; beyond this area, the track was undisturbed for approximately 120 feet leading into the area where the cars came to rest on track 2

Approximately 45 feet east of the POD, derailed cars from track 2 forced track 1 northward against the support column crash wall, heavily damaging some 400 feet of track Derailed cars first struck the crash wall 53 feet east of the POD The wall has an 80-foot gap, which is about 140 feet east of the POD, to accommodate the Dartmouth Street overhead bridge structure When the lead locomotive on Amtrak train 66 struck the MBTA train 906 locomotive, both entered the gap, damaging some 400 feet of track 3

Operations Information

Operating Procedures --Amtrak train 66 operated on the Boston division from New Haven (MP 72 3) to Boston (MP 228 7) Amtrak also operates MBTA commuter trains in the Boston area in accordance with the operating agreement of January 1, 1987, and dispatches trains and maintains physical plants in accordance with the MBTA agreement of July 1, 1984 The CETC signal and dispatching system controls the train operations on the main tracks at Boston The train dispatcher oversees about 220 trains daily

Amtrak Train 66 --According to the December 12, 1990, train performance sheets that Amtrak provided, Amtrak train 66 made seven scheduled and two unscheduled stops between New Haven and Boston The two unscheduled stops required 6 minutes at MP 127 to close a baggage car door and 4 minutes at South Attleboro (MP 192) to board passengers When the accident occurred, Amtrak train 66 was 7 minutes ahead of schedule.

Under Amtrak Air Brake and Train Handling Rules and Instructions, a locomotive engineer may use any train handling method that is within train handling guidelines for safe operation of the train To stop a train, a locomotive engineer can use the blended dynamic brakes, the automatic airbrakes, or the locomotive independent brakes The engineer of Amtrak train 66 stated that his method of braking was determined by the consist mix (type of cars and their different braking ratios) He said that the apprentice engineer had slowed Amtrak train 66 using the automatic airbrakes and a power braking method

When a locomotive engineer is braking a mixed-consist[3] passenger train, according to Amtrak airbrake instructions for the power braking method, he should reduce throttle to not greater than run 4 position and then make an initial automatic airbrake reduction Next, he should release the locomotive independent

[3]Mixed consists are passenger trains that include several types of passenger cars The consist for Amtrak train 66 included both Heritage and Amfleet equipment

brakes and reduce throttle to no greater than run 2 position, he should not increase the throttle above that position until brake release has been initiated The locomotive engineer should make additional reductions with the automatic airbrakes, as needed, to slow or stop After reaching the desired speed, he should release the automatic airbrake and increase throttle When making a stop, he should reduce throttle to idle, maintain a minimum 12-psi service reduction while stopped, and make a full application of the locomotive independent brake

Amtrak management requires that its employees be familiar with the rules and instructions that relate to their duties If in doubt about meaning or application, they are to ask their supervisor for an explanation Under Amtrak rules, the locomotive engineer is responsible for observance of signals and for control and regulation of train movement He is also responsible for instructing apprentice engineers and for ensuring that they are familiar with engine duties During the accident investigation, Amtrak officials and locomotive engineers stated that the locomotive engineer of Amtrak train 66 should have instructed the apprentice engineer to start braking the train at the Pickle Factory, a landmark structure at MP 225 7 They also said that a train operating at 100 mph could not be stopped safely if braking commenced, as was reported, at the Ruggles Street station (MP 226 2) The apprentice engineer stated that he received instruction in the power braking method in the locomotive engineer training program

Management Oversight --Amtrak management oversees train operations through an efficiency testing program, train riding, and day-to-day supervision of operating crews Amtrak policy requires that operating officials make at least 100 efficiency tests for operating rules compliance per month The goal of this program is to test every operating employee on operating rules compliance every 30 days The Amtrak efficiency testing program is on file with the FRA

The Safety Board found that in the 11 months preceding the accident, the entire crew of Amtrak train 66 had been tested on operating rules compliance The locomotive engineer had been tested 27 times, including 14 times for speed and 6 times for signals, and had no reported failures Efficiency test records indicate that during the 11 months, he had been tested in the Boston area on three occasions On November 16, 1990, he underwent a running automatic airbrake test near Back Bay station Since entering the locomotive engineer training program, the apprentice engineer had been tested five times, including twice for speed and twice for signals, and had no reported failures

The FRA inspects Amtrak's efficiency testing records and continuously monitors Amtrak's performance for regulatory compliance The engineer of Amtrak train 66 testified that FRA safety inspectors had accompanied him on over-the-road trips The FRA had also observed the performance of dispatchers operating in the centralized dispatching offices No exceptions were noted

Meteorological Information

The National Weather Service reported that at 8:23 a m on December 12, 1990, Boston had a temperature of 34° F and no rain or snow

Medical and Toxicological Information

According to hospital medical records, 278 persons were transported from the accident scene, 14 were admitted and 264 were treated for minor lacerations, contusions, and fractures and then released Amtrak reported that after the accident, an additional 175 persons filed claims stating that they had been injured as a result of the collision

Following the accident, in accordance with FRA regulations, Amtrak required that the train dispatcher and the 10 operating crewmembers from Amtrak train 66 and MBTA train 906 be toxicologically tested. Within 2 hours, the employees arrived at local hospitals, where blood and urine specimens could be taken

The FRA's contract toxicological laboratory, CompuChem Laboratories in Research Triangle Park, North Carolina, received the specimens for analysis and tested them for the presence of ethanol, amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, methaqualone, opiates, and phencyclidine All employees tested negative

Fire

At 8·24 a m , the 911 operator notified the Boston Fire Department about the accident Upon arrival at 8.25 a m ,[4] the fire department quickly extinguished several small fires around the locomotives Firefighters encountered small residual diesel fuel fires that caused dense smoke In about 2 hours, the firefighting and rescue operations were completed Nonetheless, the fire department maintained a detail for about 32 hours to prevent reignition while Amtrak and MBTA personnel removed debris from the accident site

Survival Aspects

Emergency Response --At 8·24 a m., a 911 operator received a telephone call that a train collision-derailment had occurred at Back Bay station The Massachusetts State Police Department, Boston Police Department, Boston EMS, Boston Fire Department, and Amtrak and MBTA police and emergency personnel were notified

The first fire department company responded at 8:25 a m and reported smoke from the venting system and station concourse, as well as scores of injured persons exiting the station The firefighters immediately ordered additional rescue equipment and ambulances to the scene. They descended into the tunnel to the collision-derailment, where, amid dense smoke, they conducted a search for injured passengers and discovered the two injured engineers from Amtrak train 66 inside locomotive 272 The firefighters radioed the incident commander for additional assistance, in all, 122 firefighters worked on the accident

At 8.27 a m , the MBTA police were notified of a train collision at Back Bay station. They responded with 41 officers, who assisted in evacuating passengers, controlling crowds and traffic, providing station security, escorting ambulances and emergency equipment, and directing passengers to alternative transportation

At 8 28 a m , the first EMS units on scene began setting up triage areas for active incident, primary triage, secondary triage, patient loading, and ambulance

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[4]A fire department station was on the street above the train station

staging The Boston police emergency units arrived at 8:30 a m , established an inner perimeter, and activated the mobile command post, which provided a central reporting location for the many agencies responding to the accident In addition, the fire department and EMS communications specialists set up a portable radio repeater system Such a system enables underground operations to communicate with surface personnel during disaster operations

Passenger Evacuation --According to train crewmembers, the evacuation of passengers was hampered by dense smoke that obscured the lighting in the tunnel and made breathing difficult. Crewmembers with flashlights led passengers to firefighters, who in turn evacuated them from the tunnel However, most passengers were able to exit the trains unassisted All tunnel exhaust fans were operating at the time of the derailment, and the EMS used the three emergency tunnel exits to evacuate passengers Most passengers from MBTA train 906 used the main exit from platform 2 Because the tunnel was blocked by the derailed locomotives, most passengers from Amtrak train 66 used the other tunnel emergency exit Buses and ambulances transported the injured to local hospitals and the uninjured to South Station

MBTA Train 906 Crew --Just after impact, the conductor, who had been in control car 1614, assisted passengers off the car onto the platform One assistant conductor, who was standing in the vestibule of the third car (302) at impact, heard a sound like an explosion from the rear of the train He was hit by a piece of metal and thrown onto the platform He proceeded through dense smoke to the platform exit doors and directed passengers up the stairs A second assistant conductor, who had been announcing the coming station stop, next remembered being on a stretcher en route to a hospital The third assistant conductor was stationed at the door making an announcement; he next remembered being in the hospital

Amtrak Train 66 Crew .--The two assistant conductors and the deadhead conductor stated that they were in the fifth car, coach car 21248, at impact The coach tipped at an angle to the left toward track 1 During the accident sequence, both coach doors were crushed and jammed shut As they opened emergency windows to evacuate passengers, the coach filled with smoke They assisted passengers through dense smoke along the catwalk and met emergency personnel, who guided them to the station platform

At impact, the conductor was in dining car 20238 He was thrown forward, striking his head on a counter The one passenger in this car was uninjured The conductor moved through dining car 20238 toward coach car 4702 and spoke with the lead service attendant, who assured him that the passengers in coach car 4702 did not need immediate medical attention The conductor then proceeded to coach car 21070, which had tipped on its side, and pulled out emergency windows to evacuate passengers. When the fire department arrived, the conductor and the two injured engineers were evacuated and transported to a hospital

The lead service attendant, who was sitting in dining car 20238, was thrown into the opposite seat and sustained multiple contusions He proceeded to coach car 4702; through a small opening between dining car 20238 and coach car 4702, he assisted passengers off the train He stated that the rescue activities were very "organized and efficient "

The sleeper car attendant said that he was seated inside sleeper car 2994 when the impact pushed him onto his knees He sustained a contusion to his right knee. After confirming that the passengers on the sleeper car were uninjured, he retrieved his flashlight and proceeded to the forward coach cars With the help of firefighters, he assisted and guided passengers off the train. Because of the dense smoke inside the tunnel, he left the accident site about 15 minutes later He stated that his training in emergency and evacuation procedures proved valuable during the accident evacuation

<u>MBTA Train 906 Exits</u> --Control car 1614 (lead car) and passenger cars 1525, 302, 326, 347, and 333 did not derail following the collision. The passengers exited from the doors at both ends of the cars All wheels on passenger car 315 had derailed, and the car sustained massive damage It remained upright against the stairwell housing between tracks 1 and 3 All emergency windows were removed. The west end of the car was crushed and the exit door blocked; at the east end of the car, the exit door to the platform was opened The unoccupied locomotive 1073 was destroyed. (See figure 4)

<u>Amtrak Train 66 Exits</u> --The collision destroyed the two-unit locomotive (272 and 366) of Amtrak train 66 However, the locomotive engineer's side of the cab was intact on unit 272, and both the locomotive engineer and apprentice engineer were evacuated from that side (See figure 5) The head end material handling car (1551) and the baggage car (1217) held no passengers or crew Coach car 21248 derailed and was leaning at a 40-degree angle The exit doors were jammed shut at one end and destroyed at the other end. The emergency windows on the sides offered the only possible exits (See figure 6) Coach car 21190 derailed onto track 1 and was leaning at a 20-degree angle Emergency windows had been removed and were inside the coach. The vestibule door was hanging open at one end; the other end was destroyed Coach car 21070 was upright with all wheels derailed Emergency windows had been removed and were inside the coach. The stairway at one end was slightly damaged, and the stairway at the other end was destroyed One end of dining car 20238 derailed, and the exterior of the car sustained minor damage Coach car 4702 and sleeper car 2994 did not derail, and the exteriors were not visibly damaged The baggage car (1188) and the material handling car (1552), which held no passengers or crew, sustained no damage

<u>Emergency Preparedness</u> --The city of Boston has a Comprehensive Emergency Management Plan (CEMP) that combines the four phases of emergency management mitigation, preparedness, response, and recovery. Last updated in September 1989, the CEMP was activated for this accident

The fire department has an ongoing training program in cooperation with the MBTA and the local railroads It periodically conducts drills with MBTA safety personnel in various stations to familiarize the first alarm and rescue companies with the fire safety equipment and facilities During the drills, fire department personnel inspect the standpipe system, the smoke control system, the elevators and ramps for the handicapped, and other physical features.

The city of Boston conducts disaster drills at 6-month intervals, and the participants include personnel from the police and fire departments, the civil defense agency, and hospital and rescue ambulance services. The June 1990 drill, in cooperation with the MBTA, featured a mock hazardous materials incident and included exercises in extricating passengers from trains, trolleys, and buses.

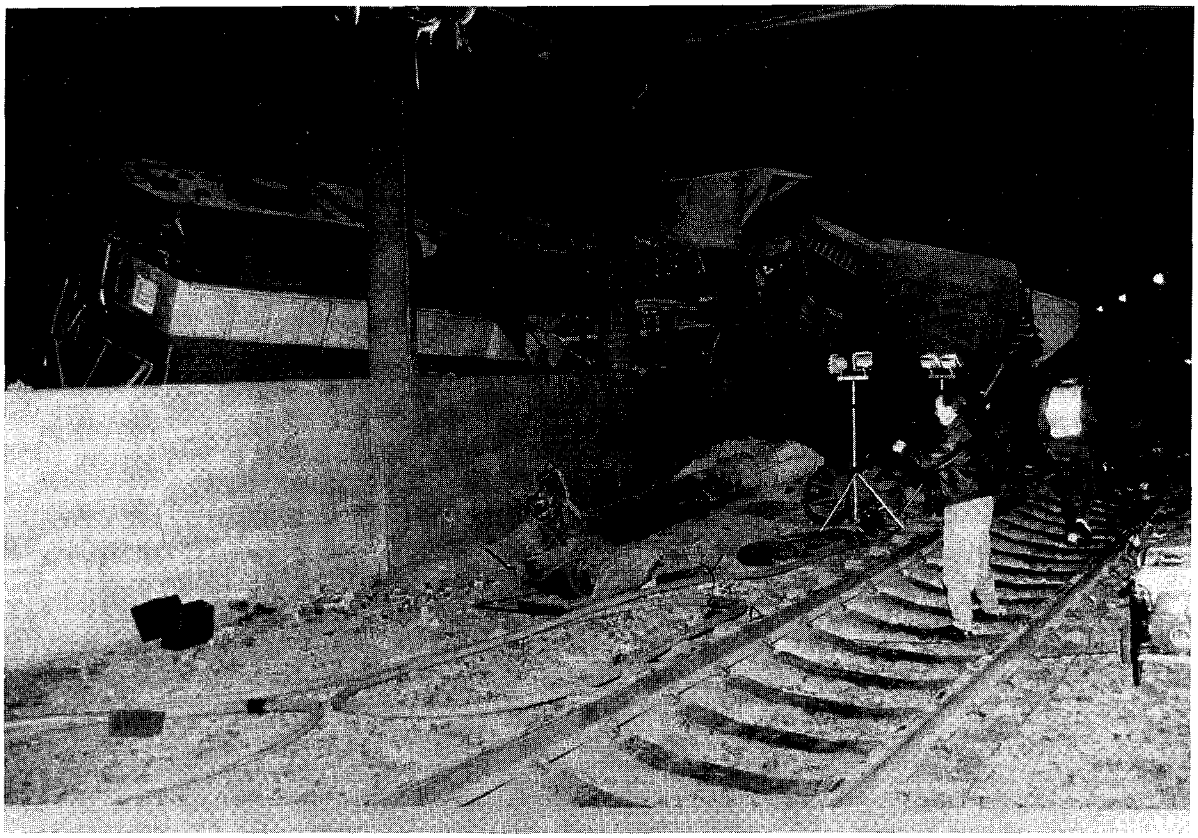

Figure 4.--MBTA train 906 wreckage.

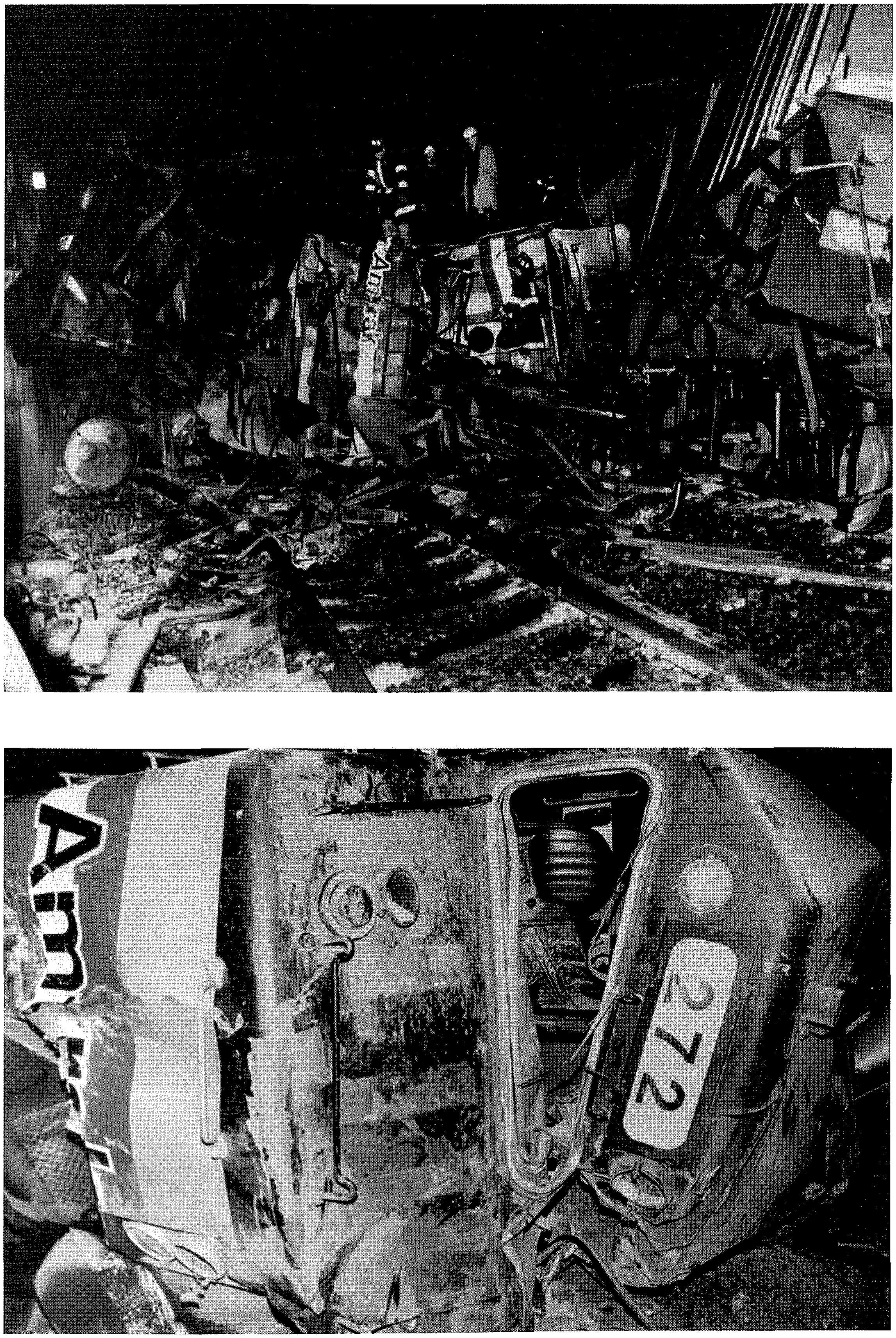

Figure 5.--Amtrak train 66 wreckage.

Figure 6.--Amtrak train 66 wreckage.

Tests and Research

Speed Indicator Test --On December 13, 1990, Safety Board investigators tested the speed indicator from locomotive 272 for proper calibration Test results showed that the speed indicator displayed 105 mph at a true speed of 110 mph According to FRA requirements in 49 Code of Federal Regulations (CFR) Part 229, locomotive speed indicators must be accurate within +/- 5 mph at speeds above 30 mph

Maintenance Records --Safety Board investigators reviewed the maintenance and repair records for locomotive units 272 and 366 on Amtrak train 66 for the 30 days before the accident On December 7, the automatic airbrake valve on locomotive 272 was replaced A locomotive engineer reported on December 10 that a minimum 6- to 8-psi reduction actually resulted in a 10-psi reduction, this condition persisted on December 12, the day of the accident A brake test that day revealed that locomotive 366's equalizing reservoir leaked

Locomotive Airbrake Valve Tests --On December 14, Safety Board investigators tested the automatic airbrake valves on the Amtrak train 66 locomotive using the test rack at the MBTA air room in Boston The test rack was verified to ensure that it functioned properly In addition, they tested the service brake valves from locomotive units 272 and 366 (The independent brake valve, which controls only the locomotive brakes, allows the locomotive engineer to release those brakes when all train brakes are applied using the automatic airbrake valve) When tested, the automatic airbrake valve functioned as designed, air pressure on both service brake valves was irregular The investigators also used an MBTA F40PH locomotive to test the automatic airbrake and service brake valves from locomotive 272 Both functioned in the same manner as they had on the test rack

The valves were again tested at the Westinghouse Air Brake Company in Wilmerding, Pennsylvania, on January 23, 1991 Test results from the service brake valves on locomotives 272 and 366 showed that the locomotive brakes were not applying as designed and that the independent braking power of both locomotive brakes was reduced Inspection revealed that compressor oil or grease had built up in the valves and that the rubber diaphragm from locomotive 366's service brake valve had an irregular surface, including surface cracks The automatic airbrake valve from locomotive 272 was tested, and it functioned as designed

Event Recorder Information --Locomotive 1073 on MBTA train 906 was equipped with a Barco paper tape speed recorder that was destroyed in the accident The tape from the Barco paper tape speed recorder on control car 1614 indicated that MBTA train 906 was traveling about 15 mph when the collision occurred

The Barco paper tape speed recorder on locomotive 272 (Amtrak train 66) was damaged in the accident The tape was torn and had no speed trace on it Amtrak locomotive 366 was equipped with a Pulse 48-hour magnetic tape event recorder, from which the data pack was recovered After the accident, at 10 05 a m , the Amtrak assistant transportation superintendent had a readout done on the Pulse readout machine at South Station Amtrak reported that it transcribed two identical strip charts of the data and kept one copy Amtrak also advised the Safety Board that for undetermined reasons, some data had not shown on the strip charts At 6 p m Safety Board investigators received the other strip chart and the Pulse data pack from Amtrak locomotive 366 and the Barco speed recorder paper tapes from Amtrak locomotive 272, MBTA locomotive 1073, and MBTA control car 1614

On December 13, Amtrak asked the Safety Board to make an identical readout of the Pulse data pack The Safety Board accompanied Amtrak personnel to South Station, where the Pulse data pack was again read out on Amtrak's Pulse readout machine This readout did not show accident data either The Pulse data pack was sent to the Safety Board laboratory in Washington, D C , where the accident data were partially recovered

Event Recorder Tests --The Safety Board laboratory received the Pulse data pack from Amtrak locomotive 366 for readout and evaluation on December 13. The laboratory's Pulse readout machine generated a strip chart of the data recovered Data from the event recorder, which recorded information about every 5 3/4 seconds, showed no signs of accident damage Safety Board engineers found an electronic end-of-tape mark[5] on the magnetic tape that prevented strip chart output of data from Route 128 to just beyond the accident Data before the end-of-tape mark indicated that the train had operated at speeds up to 110 mph between Kingston and Providence and between South Attleboro and Route 128 (See figure 7 for the Pulse magnetic tape event recorder strip chart.)

An end-of-tape mark normally indicates that all 48 hours of the tape data have been reproduced on the strip chart Pulse designed two safeguards into the event recorder system components to prevent inadvertent placement of an end-of-tape mark over the most recently recorded data The first safeguard is a ratchet mechanism inside the Pulse data pack that prevents rotation of the tape spool in the direction opposite to the recording direction The second safeguard is the manner in which the Pulse readout machine creates an end-of-tape mark The readout machine advances the tape in the recording direction away from the most recently recorded data, creates the end-of-tape mark, and then starts the transcription of data to the strip chart

From tests, Safety Board investigators determined that the Pulse 48-hour magnetic tape event recorder and its data pack from Amtrak locomotive 366, as well as the Pulse readout machine at South Station, functioned as designed Both the Pulse data pack's ratchet mechanism and the Pulse readout machine's end-of-tape mark feature also functioned as designed

Safety Board laboratory engineers found that the end-of-tape mark on the magnetic tape was 13 6 minutes long, 2 2 minutes longer than the minimum 11 4-minute end-of-tape mark that usually exists after a readout Also, this end-of-tape mark began at Route 128 (MP 217 3) and ended just beyond the accident (MP 227 45) data Given the safeguards designed into the Pulse event recorder system components, the end-of-tape mark over the most recently recorded data should not have occurred

Given that no failure of the ratchet mechanism on the end-of-tape mark feature could be found, Safety Board laboratory engineers attempted to determine

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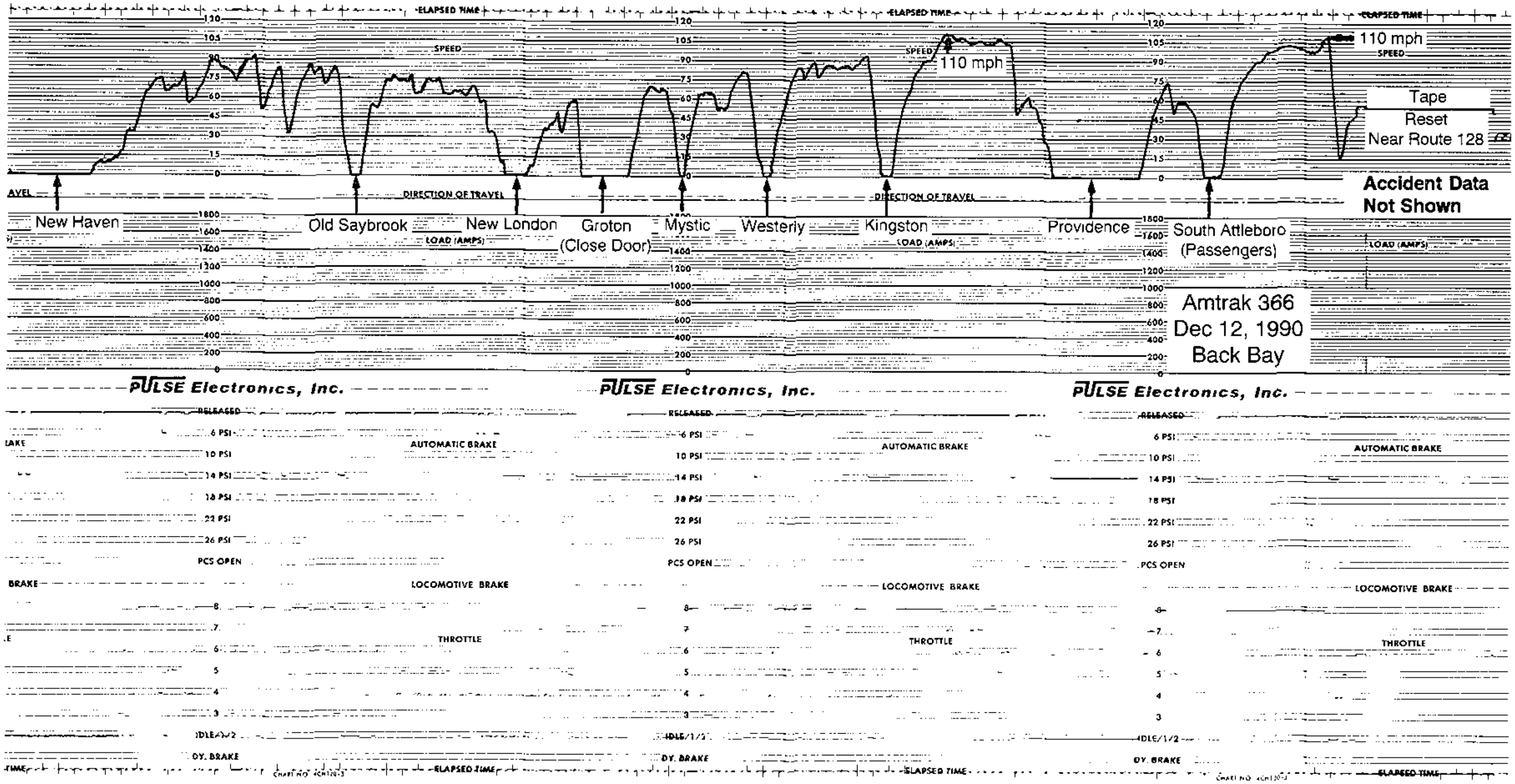
[5]On this area of a Pulse data pack tape, the recorded and synchronized reference frequency used to determine elapsed time during a readout is removed from its track (a tape has four tracks)



Not to Scale

Pulse Recorder Data

Figure 7.--Amtrak train 66 Pulse magnetic tape event recorder strip chart.

how an end-of-tape mark could have appeared on the accident magnetic tape The data pack could have been opened, the tape spool lifted up and away from the ratchet mechanism, the tape wound in the direction of the most recently recorded data, and the end-of-tape mark placed on the tape Or, the initial readout could have been made without an end-of-tape mark and the data pack could have been pulled out of the readout machine just before Route 128 (MP 217 3) data Amtrak officials stated that they do not believe either action was ever taken

Because an end-of-tape mark prevents a strip chart output of data, laboratory engineers extracted the data manually During the initial readout generated on the laboratory's Pulse readout machine, they had copied the data to 1/4-inch magnetic tape, reel-to-reel Using the reel-to-reel copy, they performed subsequent readouts and evaluations. They extracted the remaining raw data from the end-of-tape mark area and converted it to engineering units The conversions yielded information on speed, distance travelled, and brake and throttle positions Since recorded elapsed time data were not recoverable, they derived the elapsed time from the known timing on the event recorder data.

The recovered Pulse event recorder data indicate that from the last stop at Route 128, Amtrak train 66 accelerated at throttle run 8 position with brakes released to a maximum speed of 109 mph, which was achieved approximately 5,400 feet before the last recorded data at MP 227 45. A single full-service brake pressure reduction of 32 psi was recorded, it occurred 4,940 to 4,024 feet before the last recorded data A single throttle position change from maximum run 8 position to idle was recorded 4,024 to 3,127 feet before the last recorded data. Brake pressure and throttle position values remained constant throughout the remaining recorded data The last recorded speed was 76 mph, and no emergency brake application was recorded that would indicate that the pneumatic control switch (PCS) was open When the PCS has been opened by an emergency brake application, the Pulse event recorder senses it electronically The brake and throttle data are sampled and recorded about every 5 3/4 seconds Therefore, if the PCS was opened within the last 5 3/4 seconds, the emergency brakes may have been set and not recorded (For event recorder data recovered from Amtrak train 66, see figure 8)

<u>Stopping Distance Simulation Tests</u> --On December 21, 1990, a Safety Board investigation team conducted stopping distance tests between Kingston (MP 158 1) and Davisville (MP 168 3) using a train consist similar to that of Amtrak train 66 on the date of the accident The test train carried no passengers To simulate the stopping distance, the investigators used information recovered from the Pulse event recorder and provided during witness testimony When stopping the train from speeds[6] of 103 to 108 mph, the automatic airbrakes, with the independent brake released, were applied 4,950 to 4,400 feet[7] before a mark that indicated the POD. Test results showed that Amtrak train 66 would have been moving 76 to 80 mph at the POD

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[6]Based on a normal operating speed of 100 mph, -5 mph true speed error of locomotive 272 speed indicator, and 108 mph brake application shown on Pulse event recorder tape

[7]Based on the distance of Ruggles Street station platform and the distance of Amtrak train 66 brake application from the POD, using event recorder data

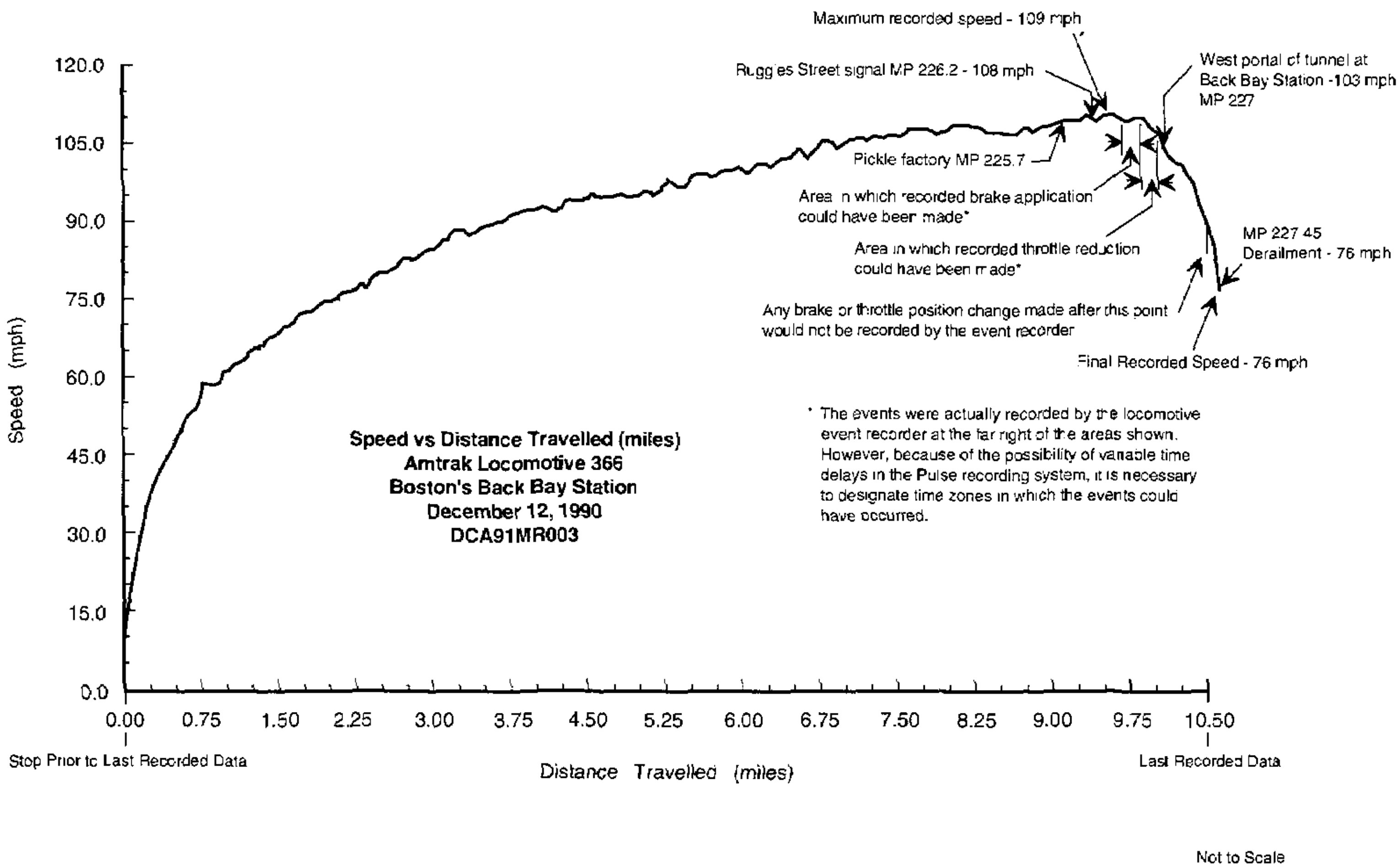

Figure 8.--Event recorder data recovered from Amtrak train 66.

Braking Speed Simulation Tests --On February 20 and 21, 1991, the Safety Board conducted 11 computer simulated braking tests on a train dynamics analyzer at Freight Master, Inc., in Fort Worth, Texas The track profile of the accident area and the physical characteristics of Amtrak train 66 consist were programmed into the simulator.

Additional conditions for each test were determined from the Pulse event recorder data and the reported operating procedures of the train's locomotive crew According to the locomotive engineer and the recovered event recorder data, the apprentice engineer began braking Amtrak train 66 at the west end of the Ruggles Street platform (about 4,950 feet before the POD) Event recorder data show a maximum recorded speed of 109 mph approaching Ruggles Street

In the simulator tests, the Safety Board used information developed from the manufacturer's braking graphs,[8] the Pulse event recorder data, and the described braking method These simulated braking tests show that moving at 109 mph, Amtrak train 66 would not have slowed to 59 mph (approximate turnover speed) in 4,950 feet using the power braking method, unless the brakes had been applied in emergency at the Ruggles Street station platform. In addition, the train would have required at least 4,950 feet to reduce speed to 32 mph in emergency braking with the locomotive brakes fully applied The turnover speed would have been exceeded in any full service braking sequence from 109 mph that the locomotive crew could have used from Ruggles Street. According to the manufacturer's braking graphs, in full service braking at 109 mph, the stopping distance would have been 9,010 feet

Amtrak's Postaccident Actions

During the Safety Board's on-scene accident investigation, Amtrak installed an advance warning sign for the 30-mph speed restriction that is in effect between MP 227 and MP 228 3. The sign was positioned near the Pickle Factory (MP 225.7) Amtrak has also installed advance warning signs for speed reduction at locations on the Northeast Corridor that have similar slowing conditions

In addition, Amtrak reports that it has altered the circuitry of the wayside automatic block signal at MP 226 2 (Ruggles), approaching Back Bay station, to display an "approach medium" signal aspect, indicating that the train is to proceed to the next signal at medium track speed (not exceeding 30 mph) If a locomotive engineer fails to initiate automatic airbrake application after passing this signal, the automatic speed control system will cause a brake application Amtrak reports that it has altered the wayside automatic block signals at five other locations on the Northeast Corridor that have similar speed reduction conditions

Amtrak has also established a postaccident event recorder procedure that requires the locomotive event recorder to remain sealed until the Safety Board or the FRA arrive on scene to witness the removal of tapes

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[8]Data developed by the car manufacturer, in conjunction with the airbrake designer, to determine deceleration rates and stopping distances for the car series involved in this accident

Locomotive Engineer Training

Sources of Information --The following information is based on statements or testimony taken from three Amtrak engineers, two recently promoted graduates of the Amtrak Locomotive Engineer Training Program, two apprentice engineers, the system general road foreman, the manager of engineer training, the director of operating rules and procedures, the coordinator for apprentices for the Boston division, the Amtrak general manager of transportation, and the Amtrak executive vice president.

Program Organization --Amtrak inaugurated its current engineer training program for passenger service in April 1987. It was developed exclusively by in-house staff The system general road foreman testified that at the time of the accident, Amtrak had offered the training to 13 classes, including the class attended by the Amtrak train 66 apprentice engineer, 141 apprentice engineers have participated in the program Of the 119 apprentices who took part in the first 12 classes, 101 became qualified engineers Selection of participants was based on employee eligibility under company seniority rules and stipulations in the Brotherhood of Locomotive Engineers (BLE) union contract.

As described by the manager of engineer training, the training program consists of four phases· classroom instruction at the engineer training school, qualification on the physical characteristics[9] of the apprentice engineers' territories, OJT, and instruction using the locomotive simulator at the IIT. He also stated that the simulator is used to evaluate apprentice engineers' performance after the OJT is completed According to the manager of engineer training, the order in which the four phases are offered varies, depending on the needs of the class being trained, and the physical characteristics and OJT phases are sometimes combined The "Locomotive Engineer Training Program Master Sheet" (see appendix C) distributed to apprentices at the engineer training school corresponds with his description of the program

The system general road foreman also stated that the program consists of four phases According to his description, Amtrak combined the physical characteristics training and OJT into a single phase, he identified the fourth phase as the "certification" of apprentice engineers on the locomotive simulator. He indicated that the time frame for the complete program ranges from 6 months to more than 1 year, depending on the needs of the individual One recently trained engineer stated that he had required 17 months to become certified

Classroom Training Phase --The classroom phase, or engineer's training school, for the program has been offered in Chicago near the IIT simulator facility and in Wilmington, Delaware, adjacent to the locomotive and car shops According to the system general road foreman, Amtrak uses the Chicago facility to instruct engineers from divisions not on the East Coast; those divisions do not need training on electric locomotives The Wilmington location is used for trainees who are to be assigned to the Northeast Corridor after they are promoted to engineer

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[9]The physical characteristics of operating territories are the operating rules, special instructions, speeds, signals, stations, and switches on the routes in a territory Qualification on physical characteristics is accomplished by riding the routes a number of times to familiarize oneself with them, after which a rules examiner or other railroad official administers an oral examination

The manager of engineer training stated that the time allotted for classroom courses taught in Chicago is 5 weeks Up to 9 weeks is allotted for the classroom courses at the Wilmington facility, depending on whether apprentice engineers are given an additional 2 weeks of instruction for electric locomotives and 2 weeks of special instruction on Northeast Operating Rules Advisory Committee (NORAC) rules He said that staff from the Amtrak rules department teach the NORAC rules in Wilmington; trainees assigned to the Chicago classes receive Amtrak rules instruction in their home division either before or after the engineers' classes The manager of engineer training explained that one of the advantages of the Wilmington facility is that the classrooms are adjacent to the shops, he estimated that 15 to 20 percent of the class time there is hands-on teaching

The apprentice engineers and recently trained engineers who had attended the classroom training made positive comments about the course, the instructors, and the evaluations they received They said that the school puts a great deal of pressure on them to learn at a fast pace One apprentice engineer recalled 14 to 15 quizzes in his class that required a score of 85 percent to pass Class size was reportedly 5 to 12 members

Physical Characteristics Familiarization --The training program requires qualification of apprentices on the significant characteristics of the territories over which they will operate Familiarization is accomplished by having apprentices ride locomotives regularly on these routes, after which a rules examiner conducts an oral examination. If the apprentices pass, they are "qualified" on those territories

The coordinator for the Boston class stated that qualification of apprentice engineers on physical characteristics before they receive their classroom instruction is not essential. The system general road foreman testified that apprentices must qualify on physical characteristics before they are permitted to run a locomotive. The instructing engineers for apprentice OJT stated that trainees with a valid permit (head end pass) to ride the locomotive operate the train on the basis of the trainees' acquired skills No engineers or apprentice engineers identified any documentation provided to show that they had passed qualification testing on the physical characteristics of their territories, and one apprentice said he had operated trains before being qualified The apprentice engineer on Amtrak train 66 stated that he completed his physical characteristics qualification before attending the class

One apprentice engineer questioned the time he was allotted for qualifying on physical characteristics and for learning train operation He said that he had expected 8 months to complete his training program after the class and expressed concern to the system general road foreman that he would need 12 months The apprentice also told Safety Board investigators that the time Amtrak allotted for learning the routes did not correspond to their difficulty As an example, he recalled being allowed 8 weeks to learn the Boston to Springfield route and 14 days to learn the more difficult New Haven to Hartford line He described the learning process for qualifying on the physical characteristics as studying, memorizing, and passing a test and cautioned that "it would be hard" for him to say that he actually knew the characteristics from these training procedures. The accident apprentice engineer's training class was the first in which successful completion of examinations on physical characteristics was required

The system general road foreman testified that he was aware of the concerns of apprentices and recently trained engineers about the program. He also said that he was "comfortable with" the times allocated for learning the physical characteristics The coordinator for the Boston classes stated that learning the physical characteristics in the training program is to be accomplished within a fixed period of time He also thought apprentices should have more time than has been allotted to learn their territories.

Simulator Training Phase --Amtrak leases time on the train simulator at IIT for both instruction and evaluation purposes. The manager of engineer training said that the current version of the training program allots 4 days for simulator training, which is to be completed before apprentices begin their OJT. The simulator instruction is for "superliner" equipment and power braking The manager of engineer training identified three "experiences" provided to apprentices during the simulator instruction phase. rules compliance, operating efficiency, and train handling. He stated that after each apprentice completes his instruction, a member of the simulator operations staff critiques his performance

Although one apprentice engineer said that the simulator is an "excellent tool," other engineers trained under the program told Safety Board investigators that their instruction on the simulator was not applicable to their equipment or territories One recently trained engineer stated that he did not find the simulator part of the training program useful, and he did not know why the section of railroad presented for his simulation was a stretch of territory in Utica, New York, that he never expected to work on Another Amtrak apprentice engineer recalled being given a section of Burlington Northern track during his simulation The manager of engineer training explained that the sections of railroad used for the simulator are intended to be "generic "

On-the-Job Training Phase --The purpose of the OJT phase is to build operating skills through experience on locomotives, according to the system general road foreman Apprentices in this training phase ride with regular engineers and operate the train under the qualified engineer's guidance The system general road foreman testified that OJT is the most critical training in the program He also stated that apprentices are assigned to the engineers for OJT based on the personalities involved and that Amtrak supervisors monitor OJT. He added that he usually observes trainees himself during this phase.

One engineer who had instructed apprentices for OJT since 1988 said that apprentices "just show up" and request that they be permitted to ride for the trip Another engineer stated that Amtrak management sometimes asks engineers whether they will consent to having an apprentice ride with them. He noted that some engineers have declined. All engineers who were questioned said that no riding assignments were made in advance for recent classes. Apprentices usually asked to ride with them when the engineers were preparing for their trip and boarded the train after showing the engineer their head end pass One recently trained engineer stated that he had been assigned to engineers for some of his OJT Another engineer trained under the program said he may have worked with 20 different engineers while on his OJT, and one other recently trained engineer stated that an apprentice had already ridden with him for OJT

Apprentice engineers in the current class told Safety Board investigators that they were selecting their own instructing engineers They said they frequently based their choice on two factors. the convenience of the trip in terms of schedule and destination and the engineers' willingness to allow the apprentices to operate the train

The system general road foreman testified that Amtrak requires coordinators from its transportation department to observe the apprentices weekly during their OJT In addition, both the coordinators and the instructing engineers are to evaluate the apprentices' progress in writing. He also said that apprentices give instructing engineers a performance evaluation form to complete after the trip (See appendix D) According to one apprentice engineer, the purpose of any forms he was given was solely to verify that he had ridden the train

No apprentice or recently trained engineer indicated to Safety Board investigators that the system general road foreman or the class coordinator had ridden with them to observe their performance One instructing engineer recalled that a training class coordinator had asked him how well individual apprentices were doing and whether a particular apprentice was ready A recently trained engineer said that he was not aware of any evaluation of his performance other than this questioning of one of his instructing engineers No engineer questioned by Safety Board investigators said he had received any training or preparation for his instructing duties

The manager of engineer training said that expected completion times for OJT ranged from 3 to 6 months, depending on the abilities of the students in the class The coordinator for the Boston classes stated that OJT was limited to 3 months, but he recalled giving one apprentice more than 1 year, another 11 months, and a third 10 months He also stated he himself had decided when apprentices were ready to leave the OJT phase in the last two classes According to the manager of engineer training, the school does not participate in the advancement of engineers after they leave the classroom phase except for scheduling the simulator, and the school staff does not follow up during OJT

Final Evaluation of Apprentices --The system general road foreman said that the final evaluation or certification of apprentices before they become engineers is done on the IIT simulator An Amtrak official oversees this procedure, which is conducted by IIT staff. When an apprentice has passed his certification examination on the simulator, the Amtrak engineer training school is notified Officials at the school in turn notify the class coordinators in the transportation department The apprentice is then considered a qualified engineer and can "mark up" for service in his division If the apprentice does not pass this examination, he returns to OJT and arrangements are made for retesting In the most recent class, some apprentices took their certification examination on the simulator before they had completed their OJT Safety Board investigators were told that currently, if apprentice engineers fail the training program, they are not permitted to return to their previous jobs and are terminated by Amtrak Apprentices stated that the possibility of losing their jobs put them under great pressure

Program Administration --The system general road foreman testified that the engineer training program is one of his responsibilities but also stated that his relationship with program staff and supervisors is advisory He said that he did not have any knowledge of Amtrak training for any crafts other than the engineer training program

The system general road foreman identified a line of authority for the engineer training program from a senior director of training in the human resources department in Washington to a director of training in Chicago. He said that the manager of engineer training at the Wilmington facility is the director of the engineer training school and reports to the Chicago-based director of training.

According to the manager of engineer training, the human resources department has administrative accountability for the school This department is also responsible for processing apprentice engineers' records pertaining to physical characteristics qualification, completion of OJT, and simulator instruction. Simulator time for final evaluation and certification at the IIT facility is scheduled through the human resources department. The manager of engineer training explained that the system general road foreman has accountability for trainees in the OJT phase of the program and that the transportation department establishes criteria to determine when an apprentice is eligible to "mark up" as an engineer.

The manager of engineer training indicated that the transportation department is responsible for the administration, follow up, and monitoring of trainees in OJT A system transportation manager from the transportation department is assigned to coordinate each class

Development and Evolution of the Program --According to the system general road foreman, Amtrak has changed the program primarily to adapt the training to the makeup of individual classes The manager of engineer training stated that the engineer training school has never been evaluated to determine how well it is performing its mission The general manager of transportation testified that he anticipates program changes, including weekly supervisory rides with apprentice engineers and selection and approval of instructing engineers before they participate in the program He also said Amtrak management was reviewing the engineer training program at the time that the Safety Board was taking depositions for the accident Safety Board investigators later learned from Amtrak's executive vice president that Amtrak initiated the management review primarily to determine whether the engineer training program complies with FRA locomotive engineer qualification requirements in 49 CFR Part 240

Engineers' and Apprentice Engineers' Concerns --A recently trained engineer stated that Amtrak should allot more time for OJT He explained that he would have benefited from additional training beyond the 17 months he had received. He added that he thought he was ready to begin working by himself but that 3 or 4 more months of training would have been useful

One apprentice engineer contrasted the duration of the engineer training program with the time allotted to complete his apprenticeship as an Amtrak electrician He recalled that the latter included 16 weeks of classes, together with a 3-year apprenticeship, and that during his apprenticeship he received 8 additional hours of classroom instruction a month

FRA Engineer Certification --On December 11, 1989, the FRA published a notice of proposed rulemaking (NPRM) to address the requirements for qualification of locomotive engineers The FRA proposed that railroads consider the following five criteria: vision and hearing acuity; sufficient knowledge of operating rules, as demonstrated by passing a written examination; sufficient train operation skills, as demonstrated by passing a performance skills test, eligibility, as demonstrated by the individual's railroad employee and motor vehicle driver record, and familiarity with the physical characteristics of the routes on which the individual would operate

In addition, the NPRM identified minimum hour requirements for instructional activities. Minimum classroom training time for experienced railroad employees and for newly hired employees was to be 158 hours and 198 hours, respectively A qualified locomotive engineer instructor was to provide a minimum of 480 hours of OJT, including at least 240 hours at the locomotive controls Simulator training could be substituted for part of this OJT time

Published on June 19, 1991, the final rule for locomotive engineer qualification in 49 CFR Part 240 became effective on September 17, 1991 The rule requires railroads to have a formal process for evaluating prospective locomotive engineers and to determine their train operation competency before permitting them to operate equipment Under the regulations, railroads must also conform to FRA-approved training programs for prospective locomotive engineer candidates, employ standard methods to identify qualified engineers, and monitor engineers' performance If a railroad hires qualified persons as locomotive engineers or employs another entity to conduct training on its behalf, that railroad may elect not to have a training program

In response to industry comments, the final rule gives railroads greater discretion in designing their qualification programs for initial and continuing locomotive engineer training The rule specifies minimum subject matter requirements and learning activities for skill performance and familiarity with physical characteristics of the territory, but it does not prescribe minimum hour requirements for instruction activities or procedures to conduct training and evaluation processes

Event Recorder Regulations --The Rail Safety Improvement Act of 1988 directed that within 18 months of its enactment on June 22, 1988, the Secretary of Transportation was to issue such rules, regulations, standards, and orders, as may be necessary to enhance safety, that require trains to be equipped with event recorders

The FRA issued an NPRM on June 19, 1991, for the drafting of event recorder regulations under 49 CFR Part 229 In September and October 1991, public hearings were conducted to receive comments about the proposed regulations. On October 30, 1991, the Safety Board provided comments generally supporting the FRA-proposed rulemaking, but asking that event recorders be required on all trains operating outside yard limits (rather than exempting freight trains with fewer than 50 cars or traveling at less than 30 mph) The Safety Board also requested that the FRA begin developing standards for a crash- and fire-resistant event recorder with a standard data recording format and for postaccident event recorder handling

ANALYSIS

General

Safety Board investigators conducted interviews, examined dispatcher records, and made track and signal inspections and tests On the basis of this information, the operation of MBTA train 906, the CETC system, and the track have been eliminated as causal factors The MBTA train 906 crew was physically fit for duty In addition, neither the weather nor alcohol or illicit drug use were contributory factors in this accident

Amtrak train 66 operated on schedule from Washington to New Haven with no defects noted At New Haven, both the operating crew and the locomotive power of Amtrak train 66 changed The operating crew was well rested and physically fit for duty No exceptions were taken to the ground inspection or airbrake testing of the train Safety Board tests of the brake system on Amtrak train 66 revealed no defects that contributed to the accident.

Factors that will be discussed include train operations and speed limits, locomotive engineer training and FRA qualification, and locomotive event recorders

The Accident

On the trip from New Haven, Amtrak train 66 made six scheduled station stops, a stop to close the baggage car door, and one unscheduled station stop The apprentice engineer made the stops under the supervision of the locomotive engineer The traincrew noted no exceptions to the operation of the train during the trip Examination of the event recorder tapes revealed that after both unscheduled stops, Amtrak train 66 exceeded the 100-mph speed limit and made up time lost on the schedule

On the trip, the apprentice engineer employed the power braking method that was taught in the locomotive engineer training program This braking method, described in Amtrak's instructions on operations and train handling, is preferred for a mixed-equipment consist and provides a smoother stop for the passengers It entails stopping or slowing the train by applying the automatic airbrakes on all cars, while keeping the locomotive under power and the locomotive independent brakes released The objective is to first minimize the train slack by applying the brakes on all cars The train is then slowed to the desired speed by reducing locomotive power and making subsequent small brakepipe applications

Initiating the service reductions sufficiently in advance of the stopping point is absolutely necessary to allow enough time to adjust the speed Stopping a train from about 100 mph using the power braking method requires about 3,000 feet more than braking the train using automatic airbrakes with locomotive independent brakes or blended dynamic brakes Because of the additional distance required for power braking, the locomotive engineer's familiarity with the braking points and his communication of that information to the apprentice are very important for proper brake applications

According to the locomotive engineer, he instructed the apprentice engineer to initiate the braking sequence for Back Bay station near the west end of the Ruggles Street station platform (MP 226 2) However, the event recorder data indicate that braking was not initiated at that location Even if the instructions had been issued there, they would have been issued too late to slow the train to comply with the 30-mph speed restriction at MP 227 The locomotive engineer stated that a 10- to 12-psi first-service reduction was made, but the train failed to slow as much as usual The event recorder data do not show that a 10- to 12-psi reduction was made

The locomotive engineer said he next instructed the apprentice engineer to apply a 32-psi full-service reduction, and the apprentice complied The locomotive engineer stated that when the train did not slow sufficiently, he made an emergency application of the automatic airbrakes near the tunnel entrance (MP 227) However, sand[10] found on the track 480 feet before the POD indicates that an emergency brake application was probably made at this point and not at MP 227 as reported. At 76 mph, the emergency brake application would have occurred no more than 4 seconds before the POD.

The event recorder data show only one full-service brake application However, because the event recorder samples data every 5 3/4 seconds and because almost 5 3/4 seconds had elapsed when the event recorder stopped recording, the emergency brake could have been applied and not have been recorded If the train had been placed in emergency braking at MP 227, the application would have been recorded because the train would have required more than 5 3/4 seconds to travel from MP 227 to the POD The Safety Board concludes that the claimed 10- to 12-psi first-service reduction was not made and that the emergency brake application was made about 480 feet before the POD, not at MP 227 as described by the locomotive crew

Amtrak train 66 continued into the curve near MP 227.4. The Safety Board concludes, based on event recorder data, that the speed of Amtrak train 66 was about 76 mph as it entered the 30-mph speed restriction for the curve into Back Bay station. Amtrak train 66 derailed and struck locomotive 1073 on the rear of MBTA train 906, which was approaching the station to make a stop on track 1

Advance Warning Devices --The advance warning sign that Amtrak installed and the signal circuitry changes to the automatic wayside block signal at MP 226 2 that Amtrak made following the accident provide a method of warning traincrews that they are about to enter the curve to Back Bay station, which has a 30-mph speed restriction The warning sign is a visual reminder to the crew of the approaching speed restriction, and the automatic speed control registers the track circuit code for "approach medium " If the engineer fails to make a brake application after passing signal 226.2, the signal indication change will audibly warn the traincrew to begin slowing the train, using a brake application, and to proceed at medium speed (not exceeding 30 mph) to the next signal. The train will automatically be brought to a stop if the crew fails to take action to reduce speed When both warnings are acknowledged, the traincrew should then be aware of the speed restriction at MP 227 and slow the train accordingly

Before the accident, the signal system approaching Back Bay station was not intended to restrict the movement of trains to less than the maximum authorized track speed of 100 mph unless the movement of other trains would interfere with the unrestricted movement or the signal system failed The 30-mph speed restriction for trains entering Back Bay station is only referenced in the special instructions of Amtrak's timetable as an operating rule restriction Amtrak relied completely on the engineer's ability to be ever cognizant of his location and to relate the special instructions, if any, to that location Thus, previous procedures did not provide redundancy in case of human failure The Safety Board is concerned that Amtrak permitted passenger trains, especially one being operated by an apprentice engineer, to operate at speeds to 100 mph in an area approaching Back Bay station without considering or providing redundancy for the

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[10]Sand is used in locomotive braking to generate more friction between locomotive wheels and the rail

consequences of human failure The Safety Board believes that Amtrak did not recognize the potential problems for the slowing condition entering Back Bay station and the possible consequences of a human failure to comply with the rules Had Amtrak taken the action before the accident that it took afterward, the accident may have been prevented

Brake Inspections and Tests--Before the accident, Amtrak train 66 underwent ground inspections and airbrake tests in Washington, D C , and New Haven No exceptions were noted with the equipment or brakes The crew operated the train from New Haven and reported no train defects or brake problems before the claimed brake problems

After the accident, the five rear cars were inspected and tested The inspections and tests revealed nothing that caused or contributed to the accident Because of accident damage, the other cars could not be tested Safety Board investigators reviewed Amtrak train 66 maintenance and repair records and found no suspect problems or repairs

The automatic airbrake valve and service brake valve from locomotive 272, together with the service brake valve from locomotive 366, were salvaged and tested at the Westinghouse Air Brake Company The automatic airbrake valve functioned as designed Tests on the two service brake valves disclosed irregular air pressure in the independent brake when the automatic brake valve was applied However, no defect was found that contributed to or caused the accident. Inspection revealed a compressor oil or grease buildup in the valves and irregular surface cracks on the rubber diaphragm of locomotive 366's service brake valve To apply the automatic brake valve, the service brake valve required irregular air pressure The service brake valve affects only the locomotive independent brakes It allows the engineer to release the locomotive independent brakes when all train brakes are applied using the automatic airbrake valve When applied with the independent brake valve handle, the independent locomotive brake applies normally

The Safety Board believes that the method of braking used by the locomotive crew of Amtrak train 66 would not have been affected by the air pressure irregularities in the service valve of the locomotive independent brakes In the power braking method, the locomotive brakes are released immediately after making an automatic airbrake application, which allows the car brakes to slow the train or bring it to a stop and eliminates the locomotive independent brakes The Safety Board concludes that the discrepancies found in the brake system of Amtrak train 66 after the accident did not affect the apprentice engineer's ability to slow the train because the independent brake was not used in the power braking method

Instructing Engineer's and Apprentice's Performance Before Derailment

The Safety Board tried to determine what actions by the engineer and apprentice may have caused or contributed to the derailment of Amtrak train 66 Their testimony and statements to investigators about their actions before the accident could not be substantiated by Safety Board analyses of the event recorder data or by examination of the brake valves The Safety Board used objective information, provided from the data recording equipment, supplemented by information provided from the locomotive crew, that is consistent with these data

The brake equipment tests and event recorder analyses showed that no initial brake application was made, that the full-service, 32-psi application was made with the locomotive brake off nearer to MP 227 than to the Ruggles Street station at MP 226.2, and that the throttle remained in the run 8 position until after the full-service brake application was made. Since sand was discovered at a location consistent with an emergency application 480 feet, or about 4 seconds, before the POD, the train was probably placed in emergency as stated by the crew but not at the location identified by them. As is reasonably clear from the testimony, which the event recorder corroborates, the apprentice followed the braking instructions given to him by the engineer, and nothing indicates that they did not continue in that mode of instruction on the approach to Back Bay station. The engineer was not chemically impaired and was familiar with the route

The Safety Board believes that if the engineer had provided the customary instructions for braking to reduce the train's speed for the curve at MP 227 4, he would have told the apprentice at about MP 225 7 to reduce the throttle from the run 8 position to the run 4 position and to follow with an initial brake application of 10 to 12 psi with no locomotive brakes Then, as Amtrak train 66 began to slow, the engineer would have instructed the apprentice to reduce the throttle to the run 1 position and make a full-service brake application Under these conditions, Amtrak train 66 train should have slowed in sufficient time to negotiate the curve Amtrak engineers and officials identified the Pickle Factory (about MP 225 7) as the point where they begin their braking of mixed consists in anticipation of the speed restriction at MP 227

Speed/distance calculations show that about 40 seconds elapsed as Amtrak train 66 traveled from the usual braking location to the point at which the event recorder indicates the full-service application was made Why the engineer did not take action to slow the train during this time is not certain Forty seconds is more than the time needed to instruct the apprentice to make a brake application and to cross the cab from the fireman's seat to the engineer's position, if necessary, to accomplish any brake application instructions that were not promptly executed. Therefore, the Safety Board postulates that the engineer did not give the directive to begin braking at the usual location and that something other than the location of the train must have been occupying his attention

One possibility is that the engineer was preoccupied with instruction tasks Another apprentice who had ridden with him on several OJT trips described his supervision as: "constantly asking questions about where I was" and "a pretty steady flow of questions about the [physical] characteristics from the time we left. . until we arrived " He also said the engineer sometimes observed him from the fireman's seat, the usual position from which supervision is conducted when an engineer has some confidence in the apprentice

The Safety Board postulates that when the engineer recognized that they had gone beyond the usual braking point for the initial application, he responded with some urgency, directing the apprentice to make a brake application, probably full service Whatever that directive was, the apprentice's execution was not consistent with acceptable braking technique Since the engineer himself did not quickly place the train in emergency, he must have initially believed that the apprentice had made the full-service application properly and that enough time remained to slow the train sufficiently to negotiate the curve The statements of both the engineer and apprentice agree that when the engineer did place the train in emergency, he reached past the apprentice for the brake valve handle; his action suggests that he intended to override the apprentice's misuse of the brake valve and throttle (the full-service brake application with the throttle at run 8 position) Investigators could not determine exactly how soon afterward the throttle was placed in the correct run 1 position By that time, no one could have done anything to prevent the accident The train slowed from 109 mph to 76 mph at the POD after the 32-psi brake application was made A speed of less than 59 mph was required to prevent the locomotive from overturning

Locomotive Engineer Training and FRA Qualification

Locomotive Engineer Training Program --Locomotive engineers were traditionally promoted from the ranks of firemen This promotional process is not always available now The prospective locomotive engineer usually acquired familiarity with the physical characteristics of the operating territories by working as a engine crewmember for many years During that time, he also acquired train-handling proficiency, judgment, and other necessary operating skills under the supervision of experienced engineers who provided individualized attention Moreover, when engineers began working in passenger service, they had usually become experienced in operating other kinds of trains before advancing to higher speed equipment.

Through its locomotive engineer training program, Amtrak is trying to provide the same basic operating knowledge and skills, but within a much shorter time frame and more structured setting Prospective engineers now receive at least part of their training in classes, and operating information pertaining to equipment and train control is technologically more advanced The time allocated for completion of an entire engineer training program is sometimes less than 1 year The Safety Board believes that locomotive engineer training is a vitally important railroad management responsibility because the long-term promotional opportunities for seasoning through the ranks are diminishing

Amtrak Locomotive Engineer Training Deficiencies --Since the apprentice engineer who operated Amtrak train 66 was trained under Amtrak's locomotive engineer training program, investigators reviewed his training, as well as the program itself The Safety Board acknowledges that the program has many constructive features (see, for example, the "Locomotive Engineer Program Master Sheet" in appendix C) However, the program also has several deficiencies, and a number of important training activities that management officials described and that are on the program master sheet apparently have not been provided Investigators also examined the relationship of the training program deficiencies to the accident events

Combining the physical characteristics qualification phase of the program with the OJT phase is one deficiency of concern to the Safety Board The outline describing the program shows different phases for these two activities, but the training is not consistently being conducted in that manner In practice, familiarizing students with the territories and teaching them operating skills have been accomplished at the same time and, for some apprentices, almost in the time frame originally allocated for OJT alone

Authorities caution that training programs for high performance skills[11] must not overload trainees' attention capacities [12] One Amtrak coordinator for OJT activities said he was not comfortable with combining the two phases, and evidence indicates that some engineers from recent classes did not believe the program allowed them to learn the territories adequately Since the training program has not been evaluated, no evidence is available to establish that the accelerated physical characteristics familiarization produces the same long-term retention of territory information that traditional familiarization did According to current training theory, after apprentices learn the territories and master basic operating skills, they should have an opportunity to combine the activities,[13] they would normally do so after learning the physical characteristics but before beginning OJT

Safety Board investigators believe that Amtrak does not necessarily assign apprentices to routes for territory familiarization in a manner consistent with apprentices' learning needs For example, some apprentices did not know how long they had to learn their routes, some apprentices believed they needed more time to learn their routes, and the length of the assignments did not necessarily correspond to the difficulty of the routes The Safety Board believes that Amtrak should administer the program so that the time allocated for physical characteristics training and the scheduling of related examinations allow apprentices to pace their learning tasks and to develop confidence in their proficiency

To promote a meaningful integration of the various learning experiences,[14] the Safety Board believes that the objectives of all major learning activities, including the riding of trains before the classroom phase, should be clearly defined When apprentices have no guidelines to use in pacing their learning tasks within an activity, their motivation, as well as their stress coping mechanisms, suffer Recognized authorities recommend that training of high performance skills be provided under conditions of "mild stress "[15]

The Safety Board is also concerned about the lack of documentation relating to apprentices' progress and development Although Amtrak officials stated that two managers regularly observe and evaluate apprentices operating trains during OJT, no recently trained engineer who was questioned recalled such observations during his training Of two experienced engineers questioned, only one recalled ever being asked to provide management officials with either a training item checklist or an oral account of how apprentices were doing. The Safety Board is concerned that because of this deficiency, some apprentices may have progressed

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[11]High performance skills are those that require more than 100 hours of training, those in which substantial numbers of individuals do not develop proficiency, and those in which expert performance is qualitatively different from that of the novice See Walter Schneider, "Training High Performance Skills Fallacies and Guidelines," Human Factors, 27, 1985, p 285

[12]Schneider, p 288, 297

[13]Schneider, p 289

[14]B M Bass and J A Vaughn, "Designing Training Programs," Training in Industry. The Management of Learning, Belmont, California Brooks/Cole Publishing Company, 1966, p 86

[15]Schneider, p 298

through OJT without gaining knowledge of their operating strengths and weaknesses

Moreover, in the absence of this documentation, Amtrak has no way to evaluate apprentices' progress in developing operating judgment and skills Instructing engineers are also unable to assess apprentices' performance development level or deficiencies in operating skills until they actually observe the apprentices operating The Safety Board urges Amtrak to revise its observation and evaluation procedures so that management and instructing engineers both have access to thorough documentation of apprentices' progress in all major learning activities This information should also be available to each apprentice to provide feedback on his training The Safety Board is concerned that Amtrak managers responsible for overseeing the training program seemed unaware that documentation was not being provided or used

Amtrak also needs to improve internal communication and coordination among training activities The investigation disclosed that most communication and coordination between activities administered by the engineer training school (classroom and simulator training) and those administered by the transportation department (physical characteristics familiarization and OJT) exist solely to facilitate scheduling, rather than ensure overall quality control of the training phase The manager of engineer training indicated that the school does not participate in the advancement of apprentices after they leave the school other than to schedule their final qualification on the IIT simulator He also said that he did not know whether the apprentice engineer on Amtrak train 66 was qualified on the territory

The Safety Board does not view this inadequate coordination as inconsequential For example, the apprentice who operated Amtrak train 66 had a low score on train handling proficiency on the IIT simulator If the instructing engineer on Amtrak train 66 had been given this information before the trip, he may have supervised the apprentice more closely Event recorder data from the locomotive showed that before the accident, the brake valve and throttle were improperly operated (that is, the throttle was in run 8 position when the full service brake application was made), and investigators determined that the engineer rather than the apprentice placed the train in emergency from the right side of the cab, albeit much too late This sequence of events suggests that the engineer may have been surprised by the apprentice's use of the controls

Training and Qualification on the IIT Simulator --The Safety Board is aware that computer-aided simulators, such as the IIT equipment used in the Amtrak engineer training program, have been increasingly accepted as training aids in the transportation industry Simulators are very useful in addressing in a controlled environment operating behaviors that are either too dangerous to undertake using actual equipment or that must be evaluated more precisely than is possible through observation alone To be most effective, this type of training must closely reproduce the conditions and operating tasks of the equipment being represented

Amtrak uses the IIT simulator for training and assessment in the engineer training program Safety Board investigators learned that neither the sections of track portrayed on the simulator nor the type of train equipment used correspond with Northeast Corridor operations The Safety Board is concerned that Amtrak has not provided simulations that more closely conform to the operations that apprentices are expected to perform after they are promoted to engineer To the extent possible, Amtrak should develop visual displays of territory, operating scenarios, and train equipment for future simulations that represent actual operations

The Safety Board is also concerned that Amtrak is using only simulations of train operations as the final qualification procedure in the engineer training program The Safety Board believes that in addition to any simulator evaluation deemed useful, final qualification of a passenger train engineer should currently include evaluations of all his or her operating tasks These tasks should be performed on all equipment the engineer will be expected to operate and over all territories on which he or she has been qualified

Additionally, the Safety Board believes that Amtrak's use of simulators for both training and evaluation should include emergency procedures, such as emergency braking and its effect on stopping distances The current IIT simulations for Amtrak do not reproduce such tasks or conditions If emergency braking and related operating procedures are not incorporated into future training classes, apprentices will continue to advance to passenger train engineer without having experienced the effects of making an emergency braking application

Training and Qualifications for Instructing Engineers --Amtrak did not provide special training for the locomotive engineers who were to serve as instructors during the physical characteristics familiarization and OJT phases No engineer questioned during the investigation reported receiving information about how to teach or evaluate the apprentices The Safety Board believes that all engineers who participate in instructional activities should receive intensive training in their teaching and evaluation tasks

In addition, the Safety Board believes that engineers performing two tasks (instructing apprentices and operating equipment) simultaneously while operating trains is a training issue that has a direct bearing on passenger safety Safety Board investigators learned that Amtrak has no systematic way of selecting engineers to serve as instructors When Amtrak inaugurated the program, management paired apprentices with engineers for physical characteristics familiarization and OJT More recently, however, the selection of an instructing engineer has frequently been left to the discretion of each apprentice

The previous instructional experience of the Amtrak train 66 engineer notwithstanding, his record included two offenses that might have disqualified him from serving as an OJT instructor if a record of no operating offenses had been required Even if less restrictive standards had been applied, the engineer might not have qualified as a supervisor of OJT because he apparently tended toward distraction while operating a train, that tendency had resulted in one of his rules violations Although Safety Board investigators were unable to determine whether the engineer was engaged in teaching tasks as Amtrak train 66 approached Back Bay station, another apprentice described the engineer's instruction in physical characteristics as intensive throughout the trips. The Safety Board believes that Amtrak should select instructing engineers on the basis of several considerations, such as an exemplary operating and safety record, evidence of disciplined attention to operating tasks under high workload conditions, and an aptitude for teaching and interpersonal skills, that are compatible with rigorous instruction

Sources of Engineer Training Program Deficiencies.--The Safety Board tried to determine why the foregoing deficiencies remained even though the engineer training program had been in place for several years and had produced 13 apprentice classes One reason is that the program had never been thoroughly evaluated As a result, coordination difficulties, documentation needs, the reactions of apprentices to their training, and scheduling deficiencies were not identified and resolved The Safety Board believes that Amtrak management needs to determine how training activities are integrated and coordinated in the program and to evaluate how these activities are contributing to or detracting from the program mission

FRA Locomotive Engineer Certification Requirements --The Safety Board is concerned that the 49 CFR Part 240 final rule may not provide sufficient guidance to the railroad industry for developing, operating, and evaluating engineer training programs The rule identifies nominal activities for acceptable programs but does not specify which standards these activities must meet The Safety Board takes particular notice of the exclusion of minimum training time requirements for activities such as physical characteristics qualification and learning operating skills The Safety Board believes that after granting preliminary approval for a railroad's program, the FRA should base final approval on a thorough assessment of all training and evaluation activities

The Safety Board also believes that the FRA should employ rigorous criteria in evaluating both new and existing programs in order to judge potential training effectiveness and to ensure an equitable approval process for all railroads All railroads submitting requests for approval should include minimum completion targets for training activities based on actual program performance Finally, the FRA should solicit comments from participants in the training programs for which approval is being sought and include such inputs in its evaluation process

Because the rule is new, the Safety Board does not have enough information to evaluate the effectiveness of the FRA approval process However, the Safety Board will monitor the FRA locomotive engineer certification program as it develops

Locomotive Event Recorders

After reviewing the event recorder strip chart of the data from Amtrak train 66, Safety Board investigators determined that the locomotive crew had operated the train in excess of the authorized 100-mph speed on three occasions Amtrak train 66 operated at speeds up to 110 mph between Kingston and Providence and between South Attleboro and Route 128, and it operated at speeds up to 109 mph between Route 128 and the POD The end-of-tape mark on the magnetic tape prevented strip chart output of data from Route 128, and Safety Board laboratory engineers had to recover that data by a manual data extraction process on the data pack

Safety Board investigators could not determine how the end-of-tape mark was placed on the accident magnetic tape Amtrak officials reported that the strip charts from their initial readout of the data pack showed no accident data The Safety Board believes that if Amtrak's current postaccident event recorder procedures had been in effect at the time of the accident, this problem could have been prevented

Survival Aspects and Emergency Response

The left side of the cab was crushed in the collision, but enough survivable space remained in the engineer's side (right) of the locomotive 272 cab Because the Amtrak train 66 locomotive engineer was standing and the apprentice engineer was seated in the engineer's side, the two survived.

Many passengers reported that they were familiar with the emergency exits Because the tunnel's exhaust fans reduced the dense smoke, most passengers were able to exit unassisted Passengers said they exited the cars through end doors, side doors, and emergency windows Most passengers described the rescue activities as excellent The Safety Board believes that emergency personnel from Boston responded promptly and in appropriate numbers to the emergency

CONCLUSIONS

Findings

1 The operation of the Massachusetts Bay Transit Authority train 906 and of the Centralized Electrical and Traffic Control system were not factors in this accident The crews of Amtrak train 66 and Massachusetts Bay Transit Authority train 906 were fit for duty

2 Although the event recorder data do not show an emergency brake application, the engineers probably applied the emergency brakes within 5 3/4 seconds of the collision

3 Recovered event recorder data indicate that the speed of Amtrak train 66 was about 76 mph as it entered the 30-mph curve into Back Bay station

4 Had Amtrak recognized the potential problems for the slowing condition entering the curve to Back Bay station earlier and taken action to correct them at that time, the accident may have been prevented.

5 The locomotive engineer failed to properly supervise the apprentice engineer in reducing the train speed in time to negotiate the 30-mph, 9° 30' curve into Back Bay station

6 The discrepancies found in the Amtrak train 66 brake system after the accident did not affect the apprentice engineer's ability to slow the train in the customary manner

7 The training program described by Amtrak management and the training experiences of several program participants differed significantly

8 Documentation of apprentices' progress in the program and coordination between the engineer training school and the transportation department are inadequate

9 Amtrak did not adequately select or prepare its instructing locomotive engineers for teaching, supervising, and evaluating apprentice engineers

10 In failing to include actual operating conditions and typical equipment that trainees are likely to encounter, Amtrak's final evaluation of its train engineer apprentices neglected important aspects of train operating competency

11 Amtrak's postaccident handling of the event recorder data pack from locomotive 366 may have caused event recorder data to be improperly covered by an end-of-tape mark and the time line to be destroyed

12 The emergency response personnel in Boston reacted promptly and in appropriate numbers to the emergency

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the apprentice locomotive engineer to reduce speed in sufficient time to negotiate the curve into Back Bay station as a result of inadequate supervision provided by the locomotive engineer Contributing to the accident was Amtrak's failure to provide adequate quality control oversight for its locomotive engineer training program, including the adequacy of selection and training for apprentices and selection and training of engineers who serve as supervisors to apprentices during on-the-job training Also contributing to the accident was Amtrak's failure to have advance warning devices for a speed reduction for the curve entering Back Bay station

RECOMMENDATIONS

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

--to the Federal Railroad Administration

> Seek and include other input, such as comments about the quality of railroad training programs, from both instructing locomotive engineers and apprentice engineers in the programs for which approval is being sought and include such input in the evaluation process (Class II, Priority Action) (R-92-1)

--to the National Railroad Passenger Corporation

> In cooperation with the Brotherhood of Locomotive Engineers and the United Transportation Union, conduct a comprehensive evaluation of the locomotive engineer training program and incorporate needed changes (Class II, Priority Action) (R-92-2)

> Develop and implement an intensive final qualification procedure that includes information from all major training activities and that verifies apprentice engineers' competency in actual operating conditions and on typical equipment they will be expected to operate (Class II, Priority Action) (R-92-3)

Incorporate in the locomotive engineer training program prescribed criteria for selecting and training engineers who are to serve as instructors (Class II, Priority Action) (R-92-4)

--to the Brotherhood of Locomotive Engineers.

In cooperation with the National Railroad Passenger Corporation and the United Transportation Union, conduct a comprehensive evaluation of the locomotive engineer training program and incorporate needed changes (Class II, Priority Action) (R-92-5)

--to the United Transportation Union:

In cooperation with the National Railroad Passenger Corporation and the Brotherhood of Locomotive Engineers, conduct a comprehensive evaluation of the locomotive engineer training program and incorporate needed changes (Class II, Priority Action) (R-92-6)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ Susan M. Coughlin
Acting Chairman

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

/s/ John A. Hammerschmidt
Member

/s/ James L. Kolstad
Member

February 25, 1992

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING/DEPOSITION

Investigation

At 9 a m on December 12, 1990, the Federal Railroad Administration notified the National Transportation Safety Board of the derailment and collision of Amtrak train 66 with MBTA commuter train 906 at Back Bay station in Boston, Massachusetts An investigator from the Eastern regional office arrived on scene at 1 30 p m , an investigator-in-charge and the Safety Board investigative team were dispatched from Washington, D C Safety Board investigators examined operations, track, mechanical components, event recorders, signals, survival factors, and human performance issues

The Federal Railroad Administration, the State of Massachusetts, the National Railroad Passenger Corporation, the Massachusetts Bay Transit Authority, the Brotherhood of Locomotive Engineers, and the City of Boston Fire Department assisted in this investigation

Hearing/Deposition

On March 21 and 22, 1991, the Safety Board staff conducted a deposition proceeding in Boston Twelve witnesses testified.

APPENDIX B

PERSONNEL INFORMATION

Willis E Copeland

The 53-year-old locomotive engineer of Amtrak train 66 began working for the New York, New Haven and Hartford Railroad in August 1957 and was promoted to locomotive engineer in October 1969 He operated in the same territory for his entire career In September 1976, Amtrak hired him in a supervisory position as a road foreman, and in January 1983, employed him as a locomotive engineer He had been working his regular assignment since the end of October 1990

Richard L Abramson

The 41-year-old apprentice engineer on Amtrak train 66 was in the OJT phase of the Amtrak locomotive engineer training program In June 1990, he entered the locomotive engineer training program; in November 1990, he completed physical characteristics qualification on two routes, the engineer training school, and simulator training; and in December 1990, he entered the OJT phase Before entering the locomotive engineer training program, he had been employed as an engine attendant at New Haven, Connecticut

APPENDIX C

OUTLINE OF LOCOMOTIVE ENGINEER TRAINING PROGRAM

AMTRAK	PROGRAM NUMBER: OEL-101
HRD - 05/87	PROGRAM LENGTH: 20-25 WKS
REV - 07/89	NO. OF UNITS: 17

LOCOMOTIVE ENGINEER TRAINING PROGRAM

MASTER SHEET

PROGRAM DESCRIPTION:

The Locomotive Engineer Training program prepares participants to become qualified locomotive engineers. The program consists of four phases.

Phase I is six to nine weeks in length and is primarily classroom activity presented by Human Resources Development (HRD). The variance in the Phase I length is because participants from Zones 1 and 2 require additional instruction on electric locomotives and NORAC operating rules. Participants are required to complete courses on Rules, Signals, the Diesel Engine, Head-End Power (HEP), Air Brakes, and Train Handling. Safety education is an integral part of each course. Upon successful completion of these courses, each participant is given instruction and laboratory experience on a locomotive simulator. Each lesson in Phase I concludes with a quiz and/or work exercises which are used to review the unit and evaluate the participant's understanding and ability. After each major unit (diesel, air brake and simulator, rules, etc.), there is a final examination and/or a list of exercises which must be completed. A minimum grade of 85% is required to pass each of these major unit exams. Upon successful completion of Phase I, the participant becomes an Engineer Trainee.

Phase II training varies in length and is carried out on each engineer trainee's home division. Each trainee is required to qualify on physical characteristics over designated portions of the home railroad within an allotted time frame. During this phase, they are under the supervision of and are evaluated and monitored by the division road foreman or his/her designee.

Phase III lasts a minimum, often longer, of twelve weeks and consists of on the job train handling (OJTH). During this phase, the engineer trainee is assigned to a Promoted Engineer selected by the division who functions as an engineer instructor. The trainee is required to operate the train frequently and for progressively increasing intervals. After each trip, the trainee is evaluated by his/her Engineer Instructor. Biweekly, the engineer trainee is evaluated by his/her road foreman who sends copies of the evaluations to HRD for training documentation and program evaluation. Upon successful completion of Phase III, the road foreman contacts the Transportation Training Group to arrange for the trainee's final evaluation (Phase IV).

Phase IV consists of final evaluation of the trainee on a locomotive simulator and begins only when the road foreman judges that the trainee is sufficiently prepared. A member of the Transportation Training Group administers and evaluates the trainee's performance on the simulator. (NOTE: This final evaluation is not administered before the end of the 12th week of OJTH.) If the trainee successfully completes this final evaluation, he/she will return to his/her home division as a qualified engineer and be ready to complete any further qualification requirements of the home railroad (e.g., whatever is necessary to become a promoted engineer). If the trainee does not successfully complete the final evaluation, he/she returns to the home division and is given additional running time. Length of time will depend upon availability of runs to make and train handling deficiencies. At the end of this additional time, the trainee is reevaluated on the simulator. If the trainee does not successfully complete the second evaluation, he/she is disqualified unless otherwise specified in contractual agreements.

Upon completion of the Locomotive Engineer Training Program, each participant is presented a Qualification Card and Certificate of Achievement.

PROGRAM OBJECTIVES:

After successfully completing this program, each participant will be able to:

1. Operate an Amtrak passenger locomotive efficiently, safely and in accordance with Amtrak and home railroad operating rules and novel requirements;

2. Troubleshoot and take corrective action for enroute mechanical and electrical malfunctions; and

3. Be a positive influence on passengers and fellow employees through personal behavior and support of Amtrak's mission and management philosophy.

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PROGRAM OUTLINE:

PHASE I

Unit I. INTRODUCTION

A. New Employee Orientation
B. Duties and Responsibilities
C. Course Overview and Requirements
D. Customer Service
E. Personal Safety

Unit II. NORAC - OPERATING RULES

A. Definitions
B. Signals
C. General
D. Manual Block System
E. Automatic Block System
F. Cab Signals
G. Interlocking
H. Radio
I. Track Out-of-Service
J. Miscellaneous

Unit III. DIESEL ELECTRIC LOCOMOTIVES

A. Orientation
B. Types
C. Amtrak's Fleet

Unit IV. DIESEL ENGINE

A. Description
B. Fuel System
C. Lubrication System
D. Cooling System
E. Governor

Unit V. RUNNING GEAR

A. Trucks
B. Draft Gear
C. Alignment Control
D. Troubleshooting

Unit VI. BASIC ELECTRICITY

A. Electron Theory
B. Magnetism
C. Electro-Magnets
D. Electrical Circuits
E. Electrical Problems

Unit VII. GENERATORS

A. General Information
B. Elementary Generators
C. Control of Output
D. Alternators and Rectifiers
E. Review

Unit VIII. HIGH VOLTAGE SYSTEMS

A. Types
B. Amperage/Voltage
C. Wheel Slip System
D. Motoring
E. Transition
F. Dynamic Braking
G. Review

Unit IX. LOW VOLTAGE SYSTEMS

A. Description
B. Sources
C. Starting Systems
D. Sanding System
E. Central Air System

Unit X. HEAD-END POWER (HEP)

A. Description
B. Trainline
C. Basic Rules

Unit XI. INSPECTIONS AND REPORTS

A. Requirements
B. Forms
C. Daily Inspection

Unit XII. AIR BRAKES

A. Orientation
B. Basic Principles
C. Compressors and Main Reservoirs
D. 26-L Locomotive Brake System
E. Car Brake Systems
F. Train Air Brake Tests
G. Speed Control/Cab Signals
H. Train Handling

Unit XIII. EMERGENCY EVACUATION

A. Introduction
B. Case Studies
C. Emergency Procedures

Unit XIV. TRAIN HANDLING ON THE SIMULATOR

A. Orientation
B. Territory
C. Equipment
D. Track
E. Signals
F. Consist Characteristics
G. Safety
H. Starting
I. Backing Up
J. Stopping
K. Speed Control
L. Enroute Troubleshooting
M. Evaluation

PHASE II - PHYSICAL CHARACTERISTICS

A. Orientation

1. Overview of Territory
2. Emergency Evacuation Review

B. Track (Main Line Layout, Spurs, Cut Outs, Sidings, Crossings, Crossovers, Grades, Mileposts, etc.)

C. Signals

D. Bridges

E. Landmarks

F. Traffic (Freight, Passenger Railroad, Passeneger Car, Pedestrians, etc.)

G. Safety Emphasis

H. Evaluation

PHASE III - ON THE JOB TRAIN HANDLING (OJTH)

A. Review of Locomotive Operation

B.1 Hands on Training
B.2 Review of Enroute Troubleshooting Procedures
B.3 Review of Emergency Procedures
B.4 Review of Physical Characteristics
B.5 Review of Operating Rules
B.6 Review of Personal Safety
B.7 Review of Orientation to Amtrak

C. OJTH and Review Evaluation

PHASE IV - FINAL EVALUATION

A. Introduction

B. Practice on Simulator

C.1 Evaluation - Performance
C.2 Evaluation - Written

D.1 Simulator Results Analysis (with Trainee)
D.2 Reschedule OJTH, if necessary

QUALIFICATION CARD AND CERTIFICATE

Participants completing the program are presented with a qualification card to carry with them and a certificate of achievement suitable for framing.

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INSTRUCTIONAL RESOURCES

MEDIA:

Workbooks and Manuals, 1 per participant:

1. Locomotive Operating Manuals (AEM-7, E-60, P-30, F-40)
2. F-40 Workbook
3. Locomotive Safety Standards & Locomotive Inspection
4. F-40 Troubleshooting Guide

Handouts, 1 per participant:

1. Rules - Hours Service Law, Form D, Car Defects
2. Air Brake Diagrams (various)
3. Programmed Instruction Booklets for Signal Indications and Signal Aspects
4. Amtrak Electrified Territory

Overhead Transparencies:

1. Rule Situations
2. Air Brake Diagrams
3. Catenary System
4. Equipment

Videotapes:

1. Getting On and Off Equipment
2. Walking or Standing on Track
3. Diesels Working on the Railroad
4. ABC's of the Diesel Engine
5. Principles of Electricity
6. AC-DC Generation
7. ABC's of Traction Motor Flashover

Films:

1. NEC Trains (filmed from locomotive exterior and cab of AEM-7)

Slides/Slidetapes:

1. Fundamentals of Air Brake
2. Train Air Brake Tests
3. Locomotive Air Brake Inspection
4. 26-L Locomotive Brake
5. 26-L Locomotive Brake Test
6. Catenary Safety

Filmstrips/LaBelle:

1. Emergency Evacuation

Other (Audio Tapes, Prepared Flipcharts, etc.):

1. AEM-7
2. F-40
3. P-30

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INSTRUCTIONAL RESOURCES (Cont'd)

MATERIALS AND EQUIPMENT:

_X_	Overhead Projector	_X_	Projection Screen
_X_	Overhead Transparency Markers	_X_	Blank Transparency Acetate
_X_	Video Monitor & VCR (Circle One: 1/2" 3/4")	___	Video Camera & Microphones
_X_	Caramate Type Synchronized Sound/Slide Projector	_X_	16mm Film Projector
___	Audio Cassette Player/Recorder	_X_	Carousel Type Slide Projector
_X_	Flipchart Stands & Pads	___	LaBelle Projector
___	Contempo Board & Markers	___	Audio Recorder Microphones
_X_	Magic Markers for Flicharts	_X_	Chalkboard & Chalk

___ Other (Supplies, Tools, Meters, etc.):

- Tent Cards/Name Tags
- Enrollment Forms
- Writing Pads
- No. 2 Pencils

INSTRUCTOR REFERENCE MATERIALS:

1. Code of Federal Regulations (FRA Part 232)
2. Management of Train Operation and Train Handling
3. NORAC Operating Rules
4. Air Brake and Train Handling (AMT-3)
5. Electrical Operating Instructions (AMT-2)
6. Safety Rules for Transportation Employees
7. Timetable Special Instructions
8. WABCO 26-1 Locomotive Brake Equipment
9. Air Brake Certification Manual (MCB-103)

ARCHIVE LOCATION: Amtrak Training Center, Wilmington, DE

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