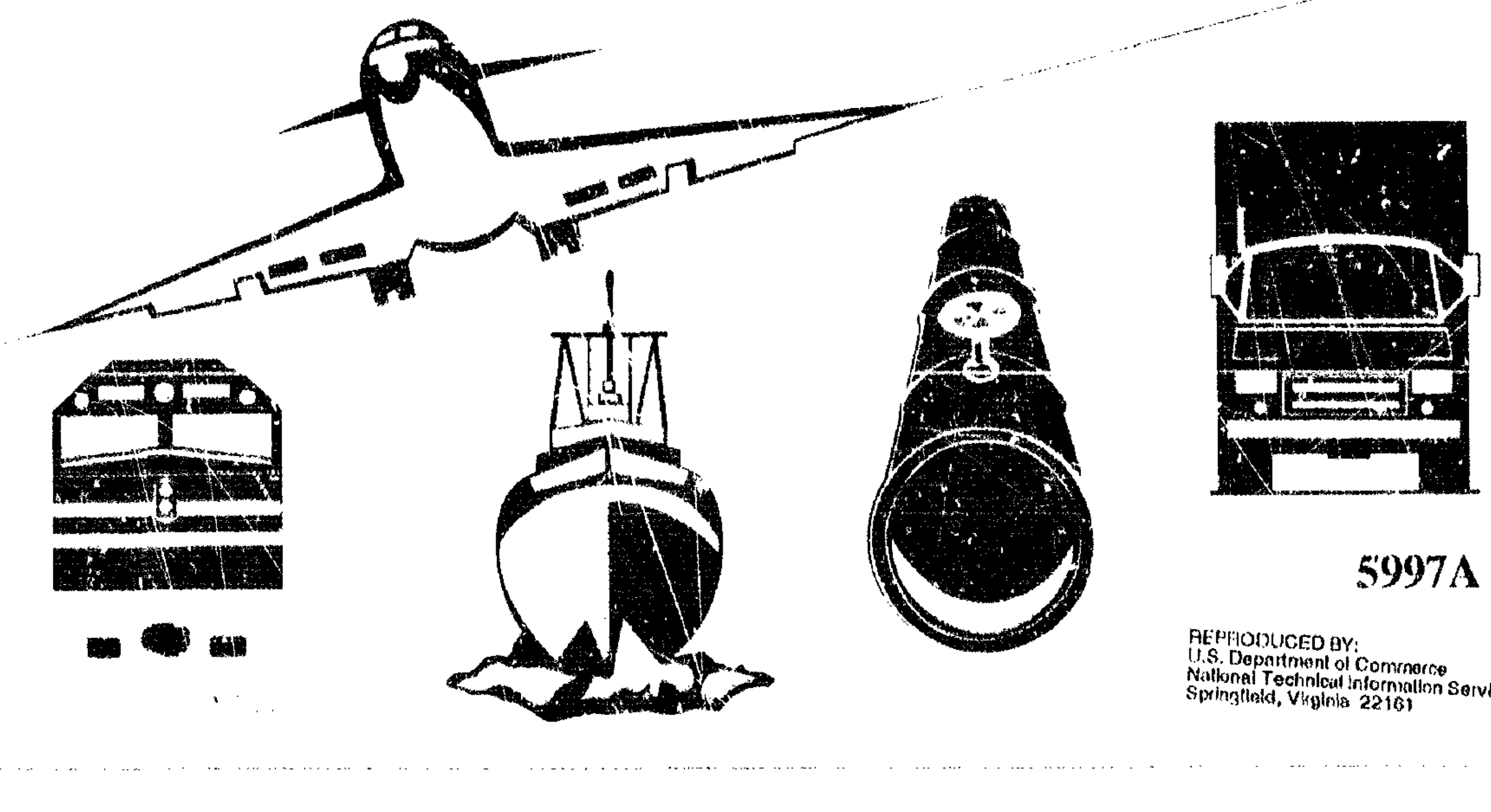
PB93-916304
NTSB/RAR-93/03

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

COLLISION BETWEEN NORTHERN INDIANA COMMUTER TRANSPORTATION DISTRICT EASTBOUND TRAIN 7 AND WESTBOUND TRAIN 12 NEAR GARY, INDIANA, ON JANUARY 18, 1993



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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

ADOPTED: December 7, 1993

NOTATION 5997A

Abstract: On January 18, 1993, Northern Indiana Commuter Transportation District (NICTD) eastbound commuter train 7, traveling from Chicago, Illinois, to South Bend, Indiana, and NICTD westbound commuter train 12, traveling from South Bend to Chicago, collided at milepost 61.1 in Gary, Indiana. Seven passengers died and 95 people sustained injuries.

The safety issues discussed in this report include the attentiveness of the engineers and the crashworthiness of self-propelled passenger rail cars in corner-to-corner collisions.

As a result of its investigation, the Safety Board issued safety recommendations to the Federal Railroad Administration, Federal Transit Administration, American Public Transit Association, Association of American Railroads, and The American Short Line Railroad Association.

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EXECUTIVE SUMMARY

At 9:34 a.m. on January 18, 1993, Northern Indiana Commuter Transportation District (NICTD) eastbound commuter train 7, traveling from Chicago, Illinois, to South Bend, Indiana, and NICTD westbound commuter train 12, traveling from South Bend to Chicago, collided at milepost (MP) 61.1 in Gary, Indiana. Train 7 and train 12 consisted of two and three passenger cars, respectively. Train 7 passed a stop signal at MP 61.2, and its lead car blocked westbound traffic where the tracks intersect. After train 12 crossed the Gary Gauntlet Bridge, it then struck train 7. As a result of the collision, 7 passengers died and 95 people sustained injuries. The estimated damage for both trains was $854,000.

The National Transportation Safety Board determines that the probable cause of the collision between the two NICTD trains was the inattentiveness of the engineer on train 7, resulting in his train passing a stop signal and partially blocking the westbound track. Contributing to the severity of the accident was the failure of the engineer on train 12 to take timely action to slow or stop his train before the collision. Contributing to the severity of the injuries was the breach of the passenger compartment in the lead cars of both trains.

The major safety issues discussed in this report are the attentiveness of the engineers and the crashworthiness of self-propelled passenger rail cars in corner-to-corner collisions.

As a result of its investigation of this accident, the Safety Board makes recommendations to the Federal Railroad Administration, Federal Transit Administration, American Public Transit Association, Association of American Railroads, and The American Short Line Railroad Association.

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20594

Railroad Accident Report

COLLISION BETWEEN
NORTHERN INDIANA COMMUTER TRANSPORTATION DISTRICT
EASTBOUND TRAIN 7 AND WESTBOUND TRAIN 12
NEAR GARY, INDIANA,
ON JANUARY 18, 1993

A National Transportation Safety Board investigative team was immediately dispatched to the accident scene in Gary, Indiana, on January 18, 1993, and the team members began their investigation of the collision between two Northern Indiana Commuter Transportation District (NICTD) trains. Following a brief accident narrative of the events preceding the collision as reconstructed from testimony, this report discusses safety issues identified by the Safety Board during the investigation. These issues include the braking performance of each train, the signal system governing the collision site, the attentiveness of the engineers, the crashworthiness of self-propelled passenger rail cars in corner-to-corner collisions, and positive train separation.

The Accident

Train 7 -- On January 18, 1993, the engineer and conductor reported for duty at 5:38 and 5:48 a.m., respectively, in Michigan City, Indiana, and departed on NICTD train 106 for Chicago, Illinois, at 5:53 a.m. Both had been off duty in accordance with the requirements of the Hours of Service Act. Train 106 arrived in Chicago at 7:53 a.m. After a scheduled layover, the crewmembers boarded NICTD train 7, which consisted of cars 27 and 14. The engineer did a predeparture air brake test and found nothing wrong with the equipment. Train 7 departed in scheduled commuter service for South Bend, Indiana, at 8:45 a.m. (See figure 1.)

At Hammond, Indiana, the conductor informed the engineer that no passengers on board requested to disembark at Clark Road, which is a flag stop according to the NICTD timetable. It is called a flag stop because passengers intending to board a train there activate a flashing strobe light mounted on a pole to flag an oncoming train to stop. Passengers on board a train who intend to disembark at Clark Road inform the conductor to make the stop. Train 7, according to NICTD officials, usually stops about twice weekly for passengers to disembark; however, passengers rarely board at this stop.

The engineer stated that after train 7 left the Hammond station and neared signal 621, he was operating the train at a speed of about 70 miles per hour (mph).[1] He said that as train 7 approached signal 621 (see figure 2), the signal indication changed from yellow (approach) to

[1] The authorized speed, according to the NICTD timetable, is 79 mph.

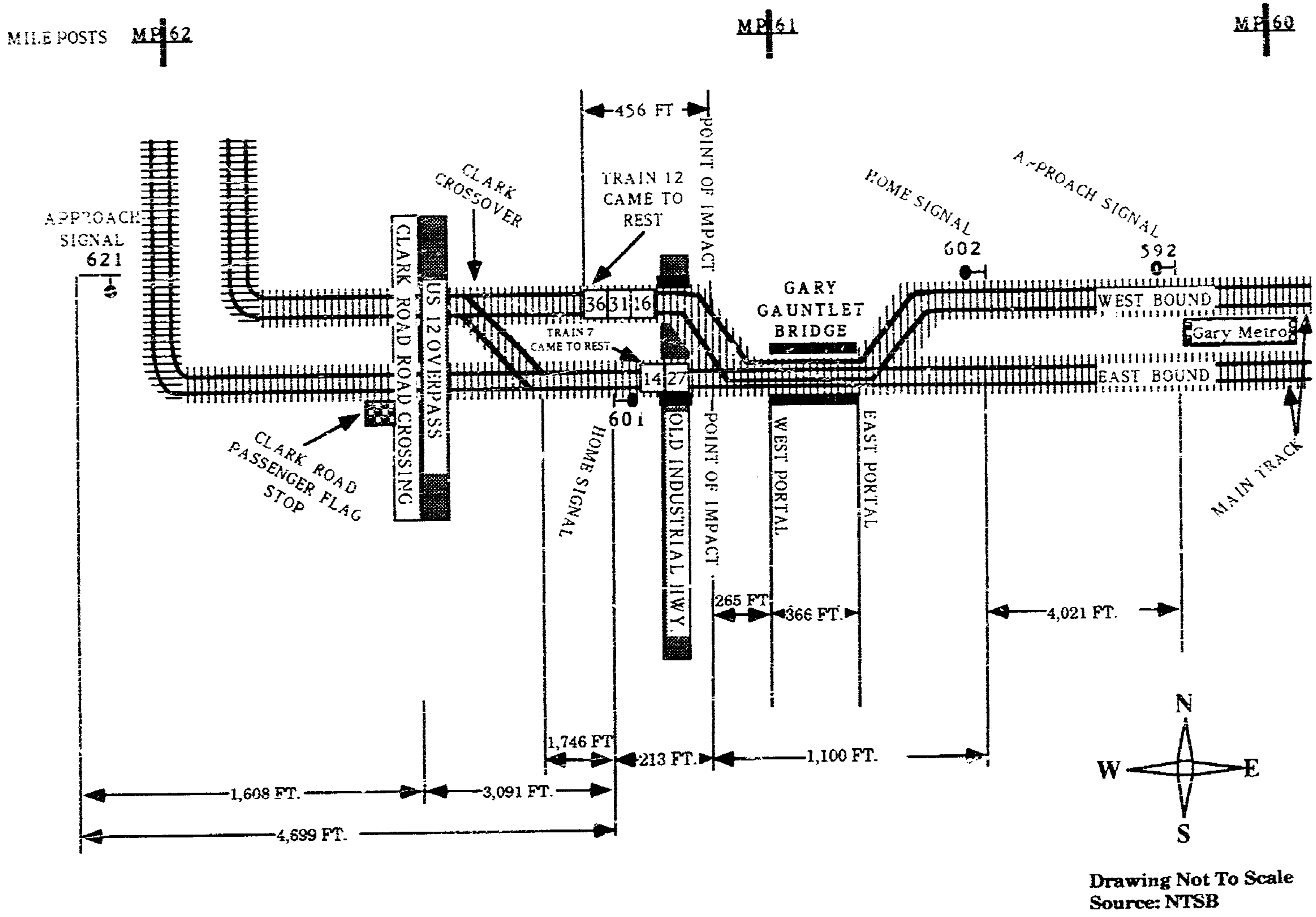

Figure 2.--Postaccident track diagram.

green over red (clear).[2] The next point of reference was the Clark Road road crossing. The engineer stated that as train 7 neared the Clark Road road crossing, he reduced the train speed to about 40 mph[3] and confirmed that no one was waiting to board train 7. The engineer said that signal 601 displayed a "clear" (green over red) indication and as the train proceeded eastward, he increased power in preparation for the 2.5-percent ascending grade at the Gary Gauntlet[4] Bridge. He said that as he proceeded eastward, he looked at his watch to see where he was in relation to his schedule. He stated, "When I looked back up, the signal looked dark."

According to rule 27 of the NICTD book of rules,[5] a signal imperfectly displayed, or the absence of a signal at a place where a signal is usually displayed, must be regarded as the most restrictive indication that can be given by that signal. (The most restrictive indication for signal 601 and all absolute block signals is a stop indication.)

The engineer of train 7 continued by saying that he recalled when the signal looked "dark," he then stood up to have a better view and saw the signal was "red." He added that the train was about 212 feet west of the signal when he saw it as "red" and that he immediately placed the train brakes in emergency application. Train 7 came to rest about 213 feet east of signal 601 and encroached the westbound track by 1 foot. (See figure 2.) The engineer said that once train 7 came to "rest," he could see train 12 on the bridge. This train collided with train 7, which pushed train 7 westward about 12 feet from the point of impact.

Train 12 -- On January 18, 1993, the engineer, the conductor, and the assigned collector/brakeman reported for duty at 6:55, 7:15, and 8:40 a.m., respectively, in Michigan City. All had been off duty in accordance with the requirements of the Hours of Service Act.

About 7:20 a.m., the engineer and conductor departed Michigan City en route to South Bend on NICTD train 403, which consisted of cars 31 and 36. At South Bend, the two cars become NICTD train 12. The engineer did a predeparture air brake test and found nothing wrong with the equipment. Train 12 departed at 8:05 a.m. in scheduled commuter service for Chicago and made its scheduled stops from South Bend to Michigan City, where car 16 was added to the consist and the assigned collector/brakeman boarded the train. The engineer made another air brake test and again found no problems with the equipment. The three-car train departed the Michigan City station at 8:45 a.m., but because of other train traffic, it was delayed 4 or 5 minutes before leaving Michigan City.

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[2] The green over red signal indicated that he had permission to proceed and no trains were in the next signal block.

[3] The speed limit, according to the NICTD timetable, is 45 mph.

[4] A track construction in which two parallel tracks converge and their inner rails cross, run parallel, and diverge again.

[5] *Chicago, South Shore, and South Bend Railroad and Northern Indiana Commuter Transportation District Rules and Regulations for Government of the Operating Department*, revised April 1990.

At Ogden Dunes, Indiana, a deadheading[6] collector/brakeman, who was also qualified as an engineer, boarded train 12 and entered the control compartment. (The normal NICTD practice is for the engineer to be alone in the control compartment while operating the train.) Both he and the engineer said that they called signals en route as prescribed by the NICTD rules[7] and noted that before the Gary Gauntlet Bridge, both signals 592 and 602, which governed the train over the bridge, displayed a proceed indication. They saw train 7 approaching, as train 12 was then on the bridge, from the west. As train 12 crossed and exited the bridge, the engineer and collector/brakeman saw that train 7 had passed signal 601. When the collector/brakeman saw train 7 was in the path of train 12, he left the control compartment, entered the passenger compartment, and dove onto a row of seats. The engineer stated that he put train 12 into emergency braking as the collector/brakeman left the control compartment. The engineer control stand is in the right corner of the control compartment. The left front corner of the train 12 lead car struck the left front corner of the train 7 lead car. Train 12 came to rest 456 feet west of its point of impact with train 7.

At 9:37 a.m., an unidentified caller notified the Gary, Indiana, 911 emergency dispatcher about the accident, and the first rescue unit responded to the collision site within 30 seconds. (This unit was returning from a previous emergency and was near the collision site.) The chief of the Gary Fire Department served as incident commander. The police, fire, and rescue services coordinated the emergency activities effectively.

Four passengers in the first car of train 7 sustained fatal injuries as a result of the collision. Of the remaining 53 people on board, 5 passengers sustained serious injuries, and 32 passengers sustained minor injuries; 14 passengers and 2 crewmembers reported no injuries. Three passengers in the first car of train 12 sustained fatal injuries. Of the remaining 137 people on board, 1 passenger sustained serious injuries, and 54 passengers and 3 crewmembers sustained minor injuries; 79 passengers reported no injuries.

In compliance with the Federal Railroad Administration (FRA) regulations, postaccident blood and urine specimens were collected from both engineers, both conductors, the on-duty collector/brakeman of train 12, and the dispatcher. The specimens were taken within 6 hours after the collision, and the test results were negative for drugs and alcohol.

According to the train engineers and passengers, the weather was clear and cold, and several inches of snow covered the ground. The National Weather Service recorded the

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[6] A term used to describe the off-duty travel of a train crewmember.

[7] General Rule 34 states, "Employees in the operating cab of an engine must communicate to each other in an audible and clear manner the name of each signal governing the movement of their train as soon as the signal aspect is clearly visible. In multiple track territory, the track number must also be called for the signal governing the movement. The signal will be observed and called again just before passing it."

temperature in the Gary area at 20° F.

Track and Operations -- The accident occurred at milepost (MP) 61.1, west of the two-span 366-foot long Gary Gauntlet Bridge. The NICTD designates its track at MP 61 as class 3 in accordance with 49 Code of Federal Regulations (CFR) 213.9. The track met all applicable FRA standards. Two sets of track approach the bridge from the east and the west on a 2.5 percent grade. Because the bridge is narrow, a frog[8] is used at each end of the structure to overlap the two tracks and form a gauntlet track. (See figure 2.) This particular track pattern allows only one direction of traffic on the bridge at a time.

The NICTD train operations in this area are governed by a timetable, track warrants, train orders, and wayside indications from an automatic block signal system.[9] Thirty-five passenger trains (17 westbound and 18 eastbound) and 6 Chicago, South Shore, and South Bend Railroad freight trains traverse this section of track each day.

Investigation

The Safety Board examined the aspects of train operations, track, signal system, mechanical equipment, and human performance. No anomalies were found in the train operations (except train handling), the track, or the mechanical equipment. Therefore, the investigation focused on the braking performance of each train, the signal system, the attentiveness of the engineers, and the crashworthiness of self-propelled passenger equipment involved in corner-to-corner collisions.

Braking Performance

The Safety Board conducted a series of stopping tests to establish the braking performance and speed of each train. The trains did not have, nor were they required to have, event recorders.[10] During the tests, equipment similar to that of the trains in the accident was operated at various speeds.

Three tests were performed during which a re-created train 7 was operated to speeds of 30, 40, and 45 mph, respectively, before emergency braking was initiated. Emergency braking was initiated about 212 feet west of signal 601 because the train 7 engineer testified that he made

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[8]A device at the intersection of two tracks to permit the wheels and flanges on one track to cross or branch the other.

[9]A series of consecutive blocks governed by a fixed signal at the entrance of a block, cab signals, or both. NICTD territory is not equipped to use cab signals.

[10]In accordance with Federal regulations, effective January 15, 1995, all trains that operate above 30 mph will be required to have event recorders.

his emergency brake application at that point. On the day of the accident, train 7 came to rest 425 feet east of the point of emergency brake initiation. The test train stopped in 117, 335, and 458 feet, respectively, from the point of braking. The test results indicate that a two-car train traveling at 44 mph when the emergency brakes were applied as the engineer testified would stop where train 7 stopped on the day of the accident.

Stopping tests were performed on a re-created three-car train 12. The tests were performed at a speed of 32 mph because the collector/brakeman stated that moments before the collision, he saw the speedometer reading at 32 mph. The test involving the emergency brakes being applied after the third car was beyond the point of impact resulted in the test train coming to rest a foot short of the 456 feet from the point of impact where train 12 was found on the day of the accident. The stopping distance test results indicate that the emergency brakes were not applied before the point of impact as the engineer on train 12 had stated.

Signal System Governing Collision Site

The area of Gary Gauntlet Bridge is within an automatic interlocking[11] operation. Each home signal consists of a three-aspect upper unit and a two-aspect lower unit on the signal mast. An approach signal precedes a home signal, which controls train movement through the interlocking. Whenever the signal system senses a train on the segment of track immediately before an approach signal and no traffic from the opposite direction, it activates a proceed indication on the home signal of the approaching train. After the home signal indicates proceed, the system changes the approach signal indication to proceed, which authorizes the train to enter the interlocking. The first train to enter the approach track segment would be the first and only train to receive the proceed indication for movement over the bridge. An opposing train would receive an approach indication at its approach signal and a red over red (stop) indication at its home signal. After the first train clears the bridge, the opposing train receives a proceed indication on its home signal.

The Gary Gauntlet Bridge automatic interlocking has an event recorder that registered the operation of the signals on a paper tape on the day of the accident. The event recorder tape indicated that from 8:23 a.m. until the accident and throughout its sequence, signal 601, the home signal of eastbound train 7, displayed a stop indication and signal 602, the home signal of westbound train 12, had a proceed indication. After train 12 passed signal 602, the proceed indication changed to a stop indication.

After receiving several postaccident reports from NICTD train crew personnel about a possible signal system failure on the automatic interlocking, Safety Board investigators thoroughly examined the signal system. Investigators inspected the signal relays, battery supplies, logic circuitry, and cables that control the automatic interlocking and the approach signals. This inspection revealed that the signal system functioned according to the FRA

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[11] An arrangement of signals and signal appliances so interconnected that their movements must succeed each other in proper sequence.

requirements and was operating as designed. All FRA tests were current. A review of FRA and NICTD signal inspection reports showed no deficiencies that would have prevented proper operation of the signal system. A review of the NICTD reports from October 2, 1992, through January 18, 1993, showed 10 trouble reports for the accident area, of which 9 reports were that "block signal 621 dropped from an approach to a stop indication." Seven of these reports were in October 1992 when a signal control board was found to be defective and was replaced; two reports disclosed no trouble within the system. The collision between trains 7 and 12 on January 18, 1993, was the 10th report.

Since the accident, the NICTD has implemented a permanent speed restriction of 20 mph through the interlocking limits. Also, a new NICTD procedure for all passenger trains passing through the interlocking at the Gary Gauntlet Bridge requires the train operator to announce over the radio the indication that is received at the approach and home signals.

Attentiveness of Train Engineers

The NICTD personnel records indicated that both engineers were qualified to perform and experienced in their duties. Both engineers denied being overtasked, preoccupied, or distracted from their duties on the day of the accident. However, the engineer of train 7 failed to comply with the stop indication on signal 601, and the engineer of train 12 did not initiate braking until after impact. Safety Board investigators examined several possible reasons for the engineers' failure to perform these actions.

Engineer of Train 7 -- According to the NICTD records, the engineer of train 7 was promoted to engineer in June 1978, and passed his last physical examination that included an eye examination and his last operating rules examination on January 30, 1990, and May 1, 1992, respectively. The engineer's regular assignment since January 1990 had been on train 7. The engineer, according to his personnel file for the 3 years preceding the accident, was cited in 1992 for improper radio procedures, failure to properly sound a whistle at a grade crossing, and speeding, for which he received one written and two verbal reprimands, respectively.

The engineer's record also shows that he was promoted to train dispatcher in November 1979. He was the train dispatcher on duty with the Chicago, South Shore and South Bend Railroad, the predecessor of the NICTD, when a head-on collision occurred in January 1985.[12] He was relieved of duty on the day of the accident and was restored to service in February 1985, because, according to the NICTD superintendent, the Chicago, South Shore and South Bend Railroad did not find him at fault in that accident. After its investigation of the accident, the Safety Board determined that the dispatcher had not acted responsibly when he failed to coordinate the movement of the two trains properly.

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[12]Railroad Accident Report--*Head-On Collision of Chicago, South Shore and South Bend Railroad Trains Nos. 123 and 218, Gary, Indiana, January 21, 1985* (NTSB/RAR-85/13).

The Safety Board examined the following possible reasons why the engineer of train 7 passed the stop indication on signal 601:

(1) his sunglasses interfered with his ability to see the signal,
(2) the sun obscured his view of the signal, and
(3) the engineer was inattentive.

The engineer of train 7 said that at the time of the accident, he was wearing a pair of sunglasses to reduce the glare from sunlight reflecting off ground snow. The engineer said that signal 601 appeared "dark" when seconds before it had been "green." To evaluate whether wearing the sunglasses may have temporarily caused the lights on signal 601 to appear "dark," sight tests were performed under environmental conditions similar to those encountered on the day of the accident. The test results revealed that the signal aspect could be easily seen and that the appropriate colors (red, yellow, and green) were clearly visible.

Safety Board investigators also considered whether the position of the sun on the day of the accident could have interfered with the train 7 engineer's view of the indications displayed on signal 601. Investigators performed several tests and found that the sun was located to the right of signal 601 and would not have interfered with an eastbound engineer's view of displayed signal indications.

Finally, Safety Board investigators examined the possibility that on the day of the accident, the engineer of train 7 was inattentive to his duties. He said that train 7 was traveling at a speed of 40 mph from the Clark crossover to signal 601. That distance of 1,746 feet can be traveled in about 30 seconds at that speed. Because signal 601 is visible in advance of the Clark crossover, the engineer should have had sufficient time to determine the status of the signal. The Safety Board considered the possibility that the engineer of train 7 may have expected a proceed indication at signal 601 based on his previous trips over this territory. Investigators reviewed the NICTD signal records from November 1, 1992, to January 17, 1993, to determine whether train 7 or train 12 usually crossed the gauntlet bridge first. The records disclosed that the engineer of train 7 encountered a proceed indication at signal 601 only slightly more than half of the time. Furthermore, on his last trip (January 15), he had encountered a stop indication at signal 601. Therefore, the engineer should not have necessarily expected a particular signal indication.

Although the Safety Board could not determine why the engineer of train 7 was inattentive to his duties, the evidence, which includes the engineer passing a stop indication at signal 601, supports the conclusion that he was inattentive to his duties. The engineer said that he continued to proceed toward the bridge even after he viewed a "dark" signal. Because the signal system was working properly, the engineer could not have received a "dark" signal. In addition, the NICTD rules state that a signal imperfectly displayed, or the absence of a signal at a place where a signal is usually displayed, should be regarded as the most restrictive indication afforded by that signal. Under these circumstances, he should have taken immediate action to stop his train. This investigation disclosed that after the engineer applied the emergency brakes, train 7 fouled the westbound track about a foot. The Safety Board concludes that the engineer of train 7 was inattentive to his duties when he passed the approach indication displayed at signal 621 and the stop indication displayed at signal 601. Because of his inattentiveness, he failed to stop at signal 601, which caused his train to foul the westbound track. The Safety Board also concludes that had the engineer acted immediately when he perceived a dark signal and applied the emergency brakes, as he should have, train 7 would have proceeded past signal 601 but would have stopped short of where it fouled the westbound track.

Engineer of Train 12 -- According to NICTD records, the engineer of train 12 was promoted to engineer on August 19, 1956, and passed his last operating rules examination and his last complete physical (included vision and color blindness tests) on June 6 and 26, 1992, respectively. His most recent eye examination before the accident, which he passed, had been on November 25, 1992. The engineer's regular assignment for more than 10 years had been on the train 12 route. His personnel file disclosed no violations for the 3 years preceding the accident.

The engineer of train 12 stated that he received a proceed indication at both signals 592 and 602. The deadheading collector/brakeman, who rode with him in the control compartment, verified this statement. The engineer recalled that he and the deadheading collector/brakeman had discussed the location of train 7; the engineer did not expect the two trains to meet at the Gary Gauntlet Bridge but to pass each other either before or after train 12 had crossed the bridge.

Both men said they initially saw the headlight of train 7 as train 12 entered the east end of the bridge. (A train travelling at 32 mph will reach the other end of the bridge in 7.8 seconds.) Because the engineer of train 12 was looking directly at the lead car of train 7 and its headlight, he was unable to ascertain the exact location or to judge the speed of train 7 while his train was on the bridge. In addition, the investigation disclosed that the bridge structure obscured the area peripheral to train 7, making it difficult for the engineer of train 12 to see any reference points west of the bridge by which to judge the movement of train 7. However, the engineer of train 12 stated that as his train exited the bridge, he observed that train 7 had proceeded past signal 601.

The engineer of train 12 stated that he expected train 7 to stop. As train 12 entered the gauntlet bridge, the deadheading collector/brakeman made several statements, according to the engineer, that train 7 did not appear to be stopping. The engineer heard the collector/brakeman's first statement, "he's still coming," when train 12 entered the east end of the bridge, and the second statement, "they're still moving" and "we're going to hit," just before or as train 12 exited the west end of the bridge (265 feet from the point of impact). The engineer said that the deadheading collector/brakeman then ran out of the control compartment and into the interior of the car as train 12 exited the west end of the bridge.

The engineer of train 12 estimated that 5 to 6 seconds elapsed between the deadheading collector/brakeman leaving the control compartment and impact. A passenger, who was seated behind the center vestibule of the first car, recalled that moments before the collision, she "looked up and saw a conductor run from the engineer's cabin to a right-hand seat and knew something was wrong." To establish the time passage, Safety Board investigators re-created the exit scene from the control compartment to the fifth row of seats in the passenger compartment. Several timed trials confirmed that between 4.7 and 5.8 seconds would likely be needed for a person in the control compartment to turn from the center window to the door, open it, run to the fifth row of seats in the passenger compartment, and sit down.

Investigation disclosed that the point of impact was 265 feet west of the west end of the Gary Gauntlet Bridge (see figure 2). The engineer of train 12 stated that when he cleared the west end of the bridge he realized that train 7 was still moving and "everything happened too fast at that point." He further stated that he "was looking for a head-on collision at that particular time because of the fact that I was moving and, as far as I could tell, train 7 was still moving, and I could see us colliding on the straight track."

At the time the engineer of train 12 exited the bridge and realized that train 7 had passed its home signal, the two trains may have been too close for the engineer of train 12 to stop his train and avert the collision. Although he could not have stopped his train in time to avoid the accident, he could have activated emergency braking and reduced the speed of his train at impact, and the severity of the accident would have been mitigated. Between 5 and 6 seconds elapsed from the time the collector/brakeman exited the control compartment and the time of impact. The engineer should have had an equal amount of time to perceive the impending collision and place train 12 in emergency braking. Furthermore, if the engineer had responded to the deadheading collector/brakeman's warnings by reducing the speed of train 12 before it exited the west portal of the bridge, the accident might have been avoided. Although the Safety Board is unable to conclusively determine whether the engineer of train 12 could have taken action to prevent the accident, the evidence shows that the actions he did take were neither timely nor appropriate.

The train 7 engineer's inattentiveness to his signal indications and the train 12 engineer's lack of initiative to slow his train raise questions about the fitness for duty of both engineers. The Safety Board is increasingly concerned about the degree to which railroad employees can safely and effectively perform their duties. Tests for the abuse of alcohol and drugs in the railroad workplace have long been legally required; however, test requirements to measure fitness-for-duty degradation caused by the effects of fatigue, stress, or other psychological and physiological conditions have not been established.

For some time, military research has focused on the development of testing methods to determine fitness-for-duty parameters, other than alcohol and drugs. Similar testing methods have been developed as well for use in civilian safety-sensitive industries that put a premium on personnel fitness. Nonintrusive, computer-based tests have been developed that measure hand-eye coordination and cognitive skills. These tests can detect impairment due to fatigue, stress, or illness as well as from alcohol or drug ingestion.

The performance of both engineers in this accident raises questions about the adequacy of procedures used by the railroad industry in determining fitness for duty. Had this railroad had a mechanism to detect abnormalities in the fitness-for-duty parameters of its safety-sensitive personnel, subnormal performance indices might have been detected for both train engineers. By their removal from service, the accident would have been preventable. Therefore, the Safety Board believes that the railroad industry should develop improved procedures for determining fitness for duty for railroad personnel in safety-sensitive positions.

Crashworthiness of Self-Propelled Passenger Cars in Corner-to-Corner Collisions

The Safety Board is concerned about the adequacy of the corner post structure in self-propelled passenger cars that allows significant inward car body intrusion and the subsequent serious injuries and fatalities in a corner-to-corner collision. This accident is the second collision investigated by the Safety Board within a 2-year period involving corner-to-corner impact of self-propelled, multiple-unit (MU) locomotive, electric-powered passenger rail cars. The first collision, on May 10, 1991, involved two unoccupied passenger trains, occurred during a switching maneuver at a very low speed (5 mph), and resulted in two minor injuries to railroad employees.[13] Because of the low impact speed, passenger compartment intrusion was minimal and no serious injuries occurred.

The self-propelled, MU, electric-powered, light-weight stainless steel construction, passenger rail cars[14] that the NICTD operates in revenue service (see figure 3) are typical of the self-propelled electric cars used in suburban commuter rail service. Each 85-foot-long, 118,000-pound car operates on 1,500 volts, direct current, supplied by overhead catenary wire. The operator controls are in a control compartment at both ends of each car. The NICTD operates its trains in consists of up to eight cars; however, the operator controls at both ends allow individual unit operation. Each car has a 93-passenger seating capacity and is generally fitted with bench seats that accommodate 2 passengers each. The benches are mounted so that the seated passengers face the middle of the car.

Train 7 Collision Damage -- Impact damage was concentrated to the left front corner on lead car 27 of train 7. (See figure 4a.) The entire left front corner post structure, which included the door structure and the front of the car, was missing from floor to roof. The car body sidewall separation extended about 27 feet.

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[13]Field Accident Brief--*Collision between Two SEPTA (Southeastern Pennsylvania Transportation Authority) Commuter Trains near Paoli, Pennsylvania, on May 10, 1991* (NTSB/NYC91FR011A).

[14]Manufactured by Nippon Sharyo Seizo Kaisha, Ltd., of Toyokawa, Japan, under a subcontract from Sumitomo Corporation of America. Louis T. Klauder and Associates of Philadelphia, Pennsylvania, provided technical support for NICTD in the preparation of the specifications and the purchase of the cars.

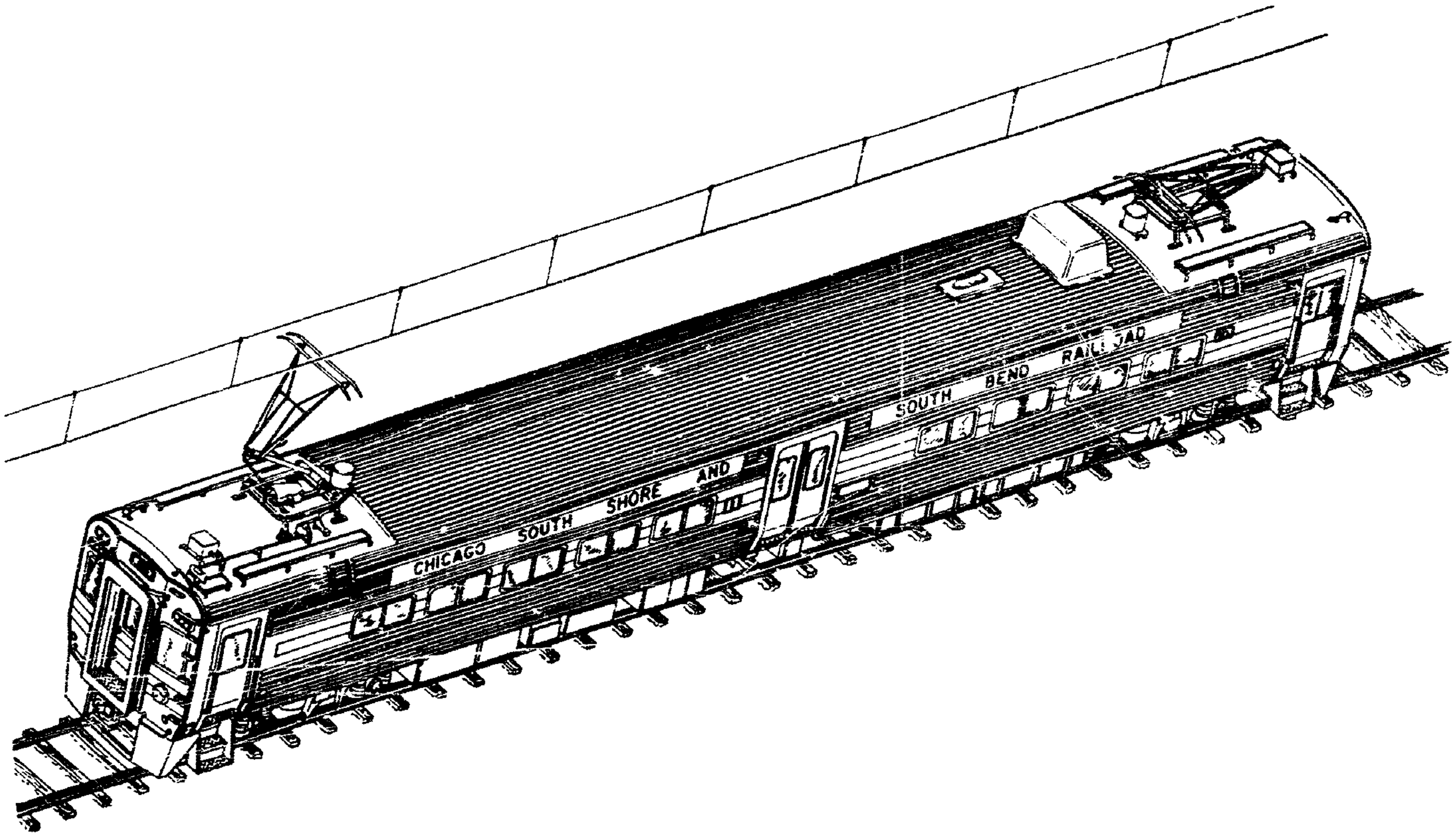
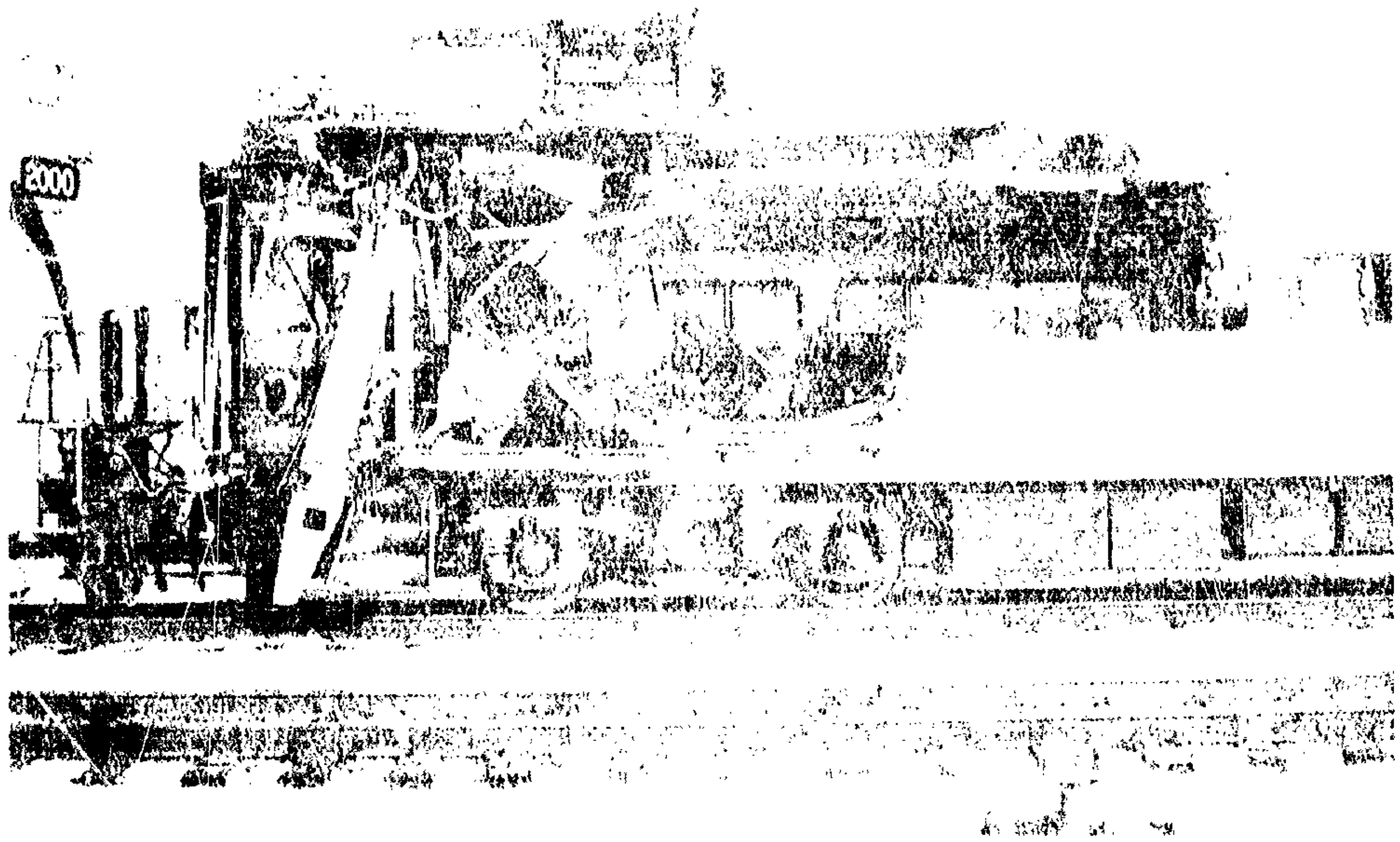


Figure 3.--Exterior view of NICTD electric passenger railroad car.
Source: *NICTD Running Maintenance and Trouble Shooting Manual*, September 1982.

a. Car 2[illegible] on train 7



b. Car 36 on train 12.

Figure 4. External damage to lead cars

An interior inspection of car 27 revealed a wall of impact debris near the sidewall separation; however, virtually no damage or debris was at the opposite end of the car. A single, large segment of car body wall had intruded and rotated into the car, and it was wedged at 90 degrees to its initial orientation across the compartment against the opposite wall. Jagged pieces of sheet metal, broken seats, and related impact debris were strewn about the area. Inspection of several damaged seats revealed that their seatbacks and legs were bent in the opposite direction to their normal mounted position and were torn from their floor mountings.

Train 12 Collision Damage -- Impact damage was concentrated to the left front corner on lead car 36 on train 12. (See figure 4b.) An external inspection of the car body side structure revealed a major separation from the left corner of the front end, extending along the left side, to and including the third window; this separation extended about 27 feet. The front left corner post structure was displaced about 1 foot inward and about 2 feet rearward from floor to roof. The door frame structure adjacent to the left front corner post appeared structurally unaffected by the impact. Significant dents, gouges, and gashes were visible in the sheet metal panel structure. A vertical indentation was on the left front panel of the car, outboard of the headlight. This indentation was about a foot from the extreme corner edge and extended from the lower frame of the left front window down to the car floor.

The car body sidewall structure from the floor to the roof, including the left front door and door pocket, was missing. The car body sidewall had separated at this point, and a jagged edge was visible along the floorline and the roofline of the separation. Inspection of several damaged seats revealed that their seatbacks and legs were bent in the opposite direction to their normal mounted position and were torn from their floor mountings. Seats, bent almost flat to a fully collapsed condition, were stacked upon the adjacent seats in a fallen-domino configuration. Impact scratches and gouges were visible on the ceiling and interior car body wall opposite the separation.

A single segment of sidewall that consisted of an intact, although visibly damaged, window and related window/sidewall framing intruded into the car. Attached to the car body wall, it was suspended about 5 feet from the floor in a horizontal orientation, pointing in a rear direction. The tube frame of the luggage rack was dented at a point opposite its attachment to the car body wall.

Event Reconstruction and Occupant Survival -- A reconstruction of the events suggests that the two car bodies overlapped about a foot and collided longitudinally left corner to left corner. The corner post structure yielded upon impact and folded inward, exposing the thin-skinned sidewall to the collision forces. As relative forward movement continued, the pressure of the opposing car body forces separated the sidewall panels at the corner posts, which experienced complete structural failure. The sidewall panels then continued to separate along their roofline and floorline in a peeling action and folded inward into the passenger compartment. The intrusion continued as the movement continued until the car bodies had sufficiently separated.

Cars 27 and 36 had the sidewall and related collision debris displace the survival space of the occupants. This displaced area is called an intrusion zone. Occupants in both cars who experienced the fatal or serious injuries were situated either within intrusion zones or adjacent to them. The fatalities resulted from blunt impact trauma to the head, upper torso, and extremities; the serious injuries were fractures, internal trauma, and lacerations. However, several occupants in both cars who were also within intrusion zones received relatively minor injuries. Occupants situated outside the intrusion zones and in other than the lead cars reported minor or no injuries. The train 12 engineer and the deadheading collector/brakeman, who retreated into a right-side fourth or fifth row seat from the control compartment of car 36, sustained only minor injuries.

Car Body Design Requirements and Considerations -- The passenger rail cars (MU locomotives) operated by the NICTD that are described in this investigation must comply with the car body design requirements for MU locomotives in 49 CFR 229.141. Several design features, such as collision posts,[15] provide for the protection of vulnerable areas of the car body in a head-on collision. (See figure 5.) By deforming on impact, collision posts absorb substantial kinetic energy (crash forces) in a coupler-to-coupler collision and prevent, or at least reduce, the tendency for car body telescoping, in which one car body intrudes longitudinally into another. However, collision posts do not afford protection to corner areas in a corner-to-corner collision because the posts are generally adjacent to the control compartment door. Moreover, the design requirements in 49 CFR 229.141 do not address car body corner post structural requirements. How much car body intrusion protection that the corner post structure will provide without such requirements before it yields and experiences complete structural failure is relative to how much kinetic energy it can absorb in a collision.

A review of the engineering documentation and discussions with the prime contractor, the subcontractor, and the NICTD technical consultant verified that the cars of trains 7 and 12 complied with FRA[16] locomotive safety standards in 49 CFR 229.141. In addition, a partially disassembled car of similar design was inspected, and the construction drawings for this car design were reviewed. The review of the as-built specifications[17] for these cars disclosed that a structural post with a minimum horizontal tearing (shear) strength of 150,000 pounds was specified for each extreme corner of a car. (This specification is a contractual document between the purchaser and supplier of the cars and not a compulsory FRA safety requirement.) The term

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[15]I-beam shaped structures that are welded to the car body underframe and roof within the control compartment door frame at each car end.

[16]The Federal agency responsible for developing and enforcing the crashworthiness standards for locomotives, self-propelled passenger cars, and control cab locomotives (locomotives without propelling motors but with one or more control stands).

[17]No. SP90034, As-built Specifications of Electric Multiple Unit Commuter Cars for Northern Indiana Commuter Transportation District (Chicago South Shore & South Bend Railroad), 1983 (corrected May 1991), pages 3-8.

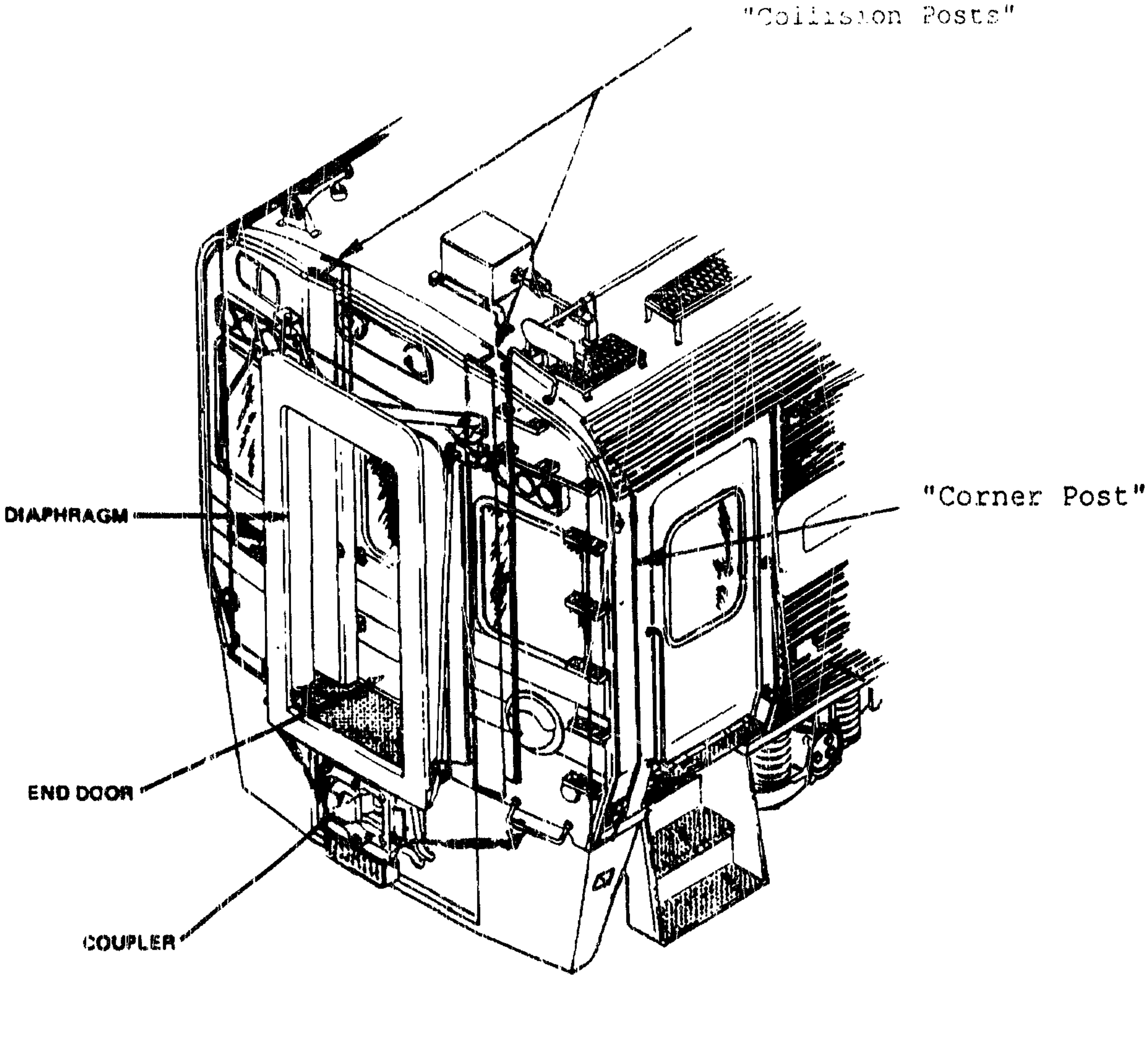

Figure 5.--Diagram showing position of collision posts and corner post on passenger rail car.

"structural post" refers to a structural element that attaches the end bulkhead (partition) to the end door and should not be confused with a structural corner post that is designed specifically for collision energy absorption and to resist car body intrusion in the corner areas.

As noted above, the design requirements in 49 CFR 229.141 do not address car body corner post structural requirements. Because this accident was the second collision within a 2-year period to involve corner-to-corner impact and it resulted in numerous fatalities and serious injuries that may have been prevented, the corner post design requirements of MU locomotives have become a significant crashworthiness issue of particular interest to the Safety Board. MU locomotive passenger cars that are built without adequate collision energy absorption structures in the corner post assemblies are vulnerable to car body intrusion in noncoupler-to-coupler collisions. The use of an energy absorption structure in the corner post assembly, similar to the collision post that is required on each side of the control compartment door, would have provided significant additional resistance to impact intrusion.

The damage that both trains sustained after the initial impact resulted from the action of dynamic forces that caused the left front corner and sidewall of the passenger compartment of each car to experience a complete structural failure and intrude inward. Because no structure was available in the corner post areas to successfully absorb the crash forces of the collision, the substantial car body intrusion into each car left no survival space in the left front areas of either car. Consequently, the collision produced numerous fatalities and serious injuries. The Safety Board concludes that the use of collision energy absorption structures in the corner post assemblies of these rail cars would have decreased the impact intrusion in this collision and may have prevented or substantially reduced the number of fatalities and serious injuries.

During the investigation of this accident, the Safety Board reviewed the FRA accident report database to detect a possible correlation between car body crashworthiness and structural design deficiencies in passenger rail cars. The Safety Board also reviewed data from its *Railroad Accident Reports--Brief Format of 1988-91 Accidents*. A comprehensive analysis could not be performed because the database of detailed passenger rail car accident damage information was inadequate. Nevertheless, the review indicated that nonpowered light-rail and subway passenger cars are also vulnerable to car body intrusion because they are often constructed to the same design specifications and exposed to the same collision energy forces as the MU locomotive passenger cars. The April 1993 issue of *Railway Age* reported that about 1,300 passenger rail cars are scheduled for delivery this year and that about 2,300 cars (all types) are anticipated to be ordered in 1994-98. A crash energy performance standard should be extended to all passenger rail cars for which a need is demonstrated, especially lead cars.

The FRA has major responsibility for developing and enforcing safety standards; however, other organizations, government and private, share in this responsibility. As a Federal financial assistance agency, the Federal Transit Administration (FTA) provides grants to urban mass transit projects. Because these FTA grants fund the costs of transit acquisition, construction, and operations as well as improvement to existing facilities and equipment, the FTA has a responsibility to ensure the equipment purchased through FTA funding meets the highest safety standards. Additionally, the American Public Transit Association (APTA), as a nonprofit international organization representing the transit industry in the private sector, should also have an interest in promoting action that would enhance the safety of passengers that use public transit.

The Safety Board realizes that the FTA does not regulate the rapid transit industry and that most APTA members do not fall under FRA regulations. However, because both the FTA and the APTA have an influential leadership role in the transit industry, they are in a position to encourage the transit industry to voluntarily adopt the FRA safety standards as guidelines for purchasing new cars. Therefore, the Safety Board believes that the FRA, in cooperation with the FTA and the APTA, should study the feasibility of providing car body corner post structures on all self-propelled passenger cars and control cab locomotives to afford occupant protection during corner collisions. If feasible, the FRA should amend the locomotive safety standards accordingly.

Positive Train Separation

The Safety Board is strongly committed to the development of a train control system for U.S. railroads that would provide the positive separation of trains and has actively pursued the issue for more than a score of years. This issue has appeared on the Safety Board "Most Wanted List" of transportation safety issues since its inception in September 1990.

After a May 1986 rear-end train collision at Brighton, Massachusetts,[18] the Safety Board recommended that the FRA promulgate Federal standards to require the installation and operation of a train control system on mainline tracks which will provide for positive separation of all trains (R-87-16). This recommendation is classified "Open--Acceptable Response." Then, after an August 1990 train collision and derailment at Sugar Valley, Georgia,[19] the Safety Board recommended that the FRA, the Association of American Railroads (AAR), and the Railway Progress Institute (RPI), in conjunction, expand the effort now being made to develop and install an Advanced Train Control System (ATCS) for the purpose of positive train separation (R-91-25, -31, and -32, respectively). These recommendations are classified "Open--Acceptable Response." Later, after an August 1991 head-on train collision near Ledger, Montana,[20] the Safety Board recommended that the FRA, the AAR, and the RPI, in conjunction, establish a

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[18]Railroad Accident Report--*Rear End Collision between Boston and Maine Corporation Commuter Train No. 5324 and Consolidated Rail Corporation Train TV-14, Brighton, Massachusetts, May 7, 1986* (NTSB/RAR-87/02).

[19]Railroad Accident Report--*Collision and Derailment of Norfolk Southern Train 188 with Norfolk Southern Train G-38 at Sugar Valley, Georgia, August 9, 1990* (NTSB/RAR-91/02).

[20]Railroad Accident Report-- *Head-On Collision between Burlington Northern Railroad Freight Trains 602 and 603 near Ledger, Montana, on August 30, 1991* (NTSB/RAR-93/01).

firm timetable that includes, at a minimum, dates for final development of required ATCS hardware, dates for implementation of a fully developed ATCS, and a commitment to a date for having the ATCS ready for installation on the general railroad system (R-93-12, -13, and -15, respectively). In December 1993, the Safety Board received responses to these recommendations from the FRA, the AAR, and the RPI. The recommendations will remain classified "Open--Await Response" while Safety Board staff reviews the three responses.

A positive train separation system, such as the ATCS, would be capable of monitoring an engineer's operation of a train. When the engineer of train 7 failed to slow his train for the stop indication on signal 601, the ATCS would have intervened, applied the train brakes, stopped train 7 short of the signal, and thus averted the accident. The collision between the two NICTD passenger trains is yet another accident that could have been prevented had a positive train separation system been in place and operational. The Safety Board urges the U.S. railroad industry to continue to work on a positive train separation system so that tragedies similar to the Gary, Indiana, train collision can be eliminated.

Conclusions

1. No anomalies or deficiencies were evident in the train operations (except train handling), track, signal system, or mechanical equipment. Neither engineer was impaired by drugs or alcohol or a lack of rest. Both engineers were experienced in and qualified to perform their duties.

2. The engineer of train 7 was inattentive to his duties when he passed the approach indication displayed at signal 621 and the stop indication displayed at signal 601. Because of his inattentiveness, he failed to stop at signal 601, which caused his train to foul the westbound track.

3. Had the engineer of train 7 acted immediately when he perceived a dark signal and applied the emergency brakes, as he should have, train 7 would have proceeded past signal 601 but would have stopped short of where it fouled the westbound track.

4. At the time the engineer of train 12 realized that train 7 had passed its home signal, the two trains may have been too close for the engineer of train 12 to stop his train and avert the collision; however, if he had applied his brakes at this time, the severity of the accident would have been mitigated.

5. Although the Safety Board is unable to conclusively determine whether the engineer of train 12 could have taken action to prevent the accident, the evidence shows that the actions he did take were neither timely nor appropriate.

6. The use of collision energy absorption structures in the corner post assemblies of these rail cars would have decreased the impact intrusion in this collision and may have prevented or substantially reduced the number of fatalities and serious injuries.

7. The collision between the two trains could have been prevented had a positive train separation system been in place and operational.

8. The performance of both engineers in this accident raises questions about the adequacy of procedures used by the railroad industry in determining fitness for duty.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision between the two Northern Indiana Commuter Transportation District trains was the inattentiveness of the engineer on train 7, resulting in his train passing a stop signal and partially blocking the westbound track. Contributing to the severity of the accident was the failure of the engineer on train 12 to take timely action to slow or stop his train before the collision. Contributing to the severity of the injuries was the breach of the passenger compartment in the lead cars of both trains.

Recommendations

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

--to the Federal Railroad Administration:

> In cooperation with the Federal Transit Administration and the American Public Transit Association, study the feasibility of providing car body corner post structures on all self-propelled passenger cars and control cab locomotives to afford occupant protection during corner collisions. If feasible, amend the locomotive safety standards accordingly. (Class II, Priority Action) (R-93-24)

--to the Federal Transit Administration:

> Cooperate with the Federal Railroad Administration to study the feasibility of providing car body corner post structures on all self-propelled passenger cars and control cab locomotives to afford occupant protection during corner collisions. (Class II, Priority Action) (R-93-25)

--to the American Public Transit Association:

Cooperate with the Federal Railroad Administration to study the feasibility of providing car body corner post structures on all self-propelled passenger cars and control cab locomotives to afford occupant protection during corner collisions. (Class II, Priority Action) (R-93-26)

Develop improved procedures for determining fitness for duty for railroad personnel in safety-sensitive positions. (Class II, Priority Action) (R-93-27)

--Association of American Railroads:

Develop improved procedures for determining fitness for duty for railroad personnel in safety-sensitive positions. (Class II, Priority Action) (R-93-28)

--The American Short Line Railroad Association:

Develop improved procedures for determining fitness for duty for railroad personnel in safety-sensitive positions. (Class II, Priority Action) (k-93-29)

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