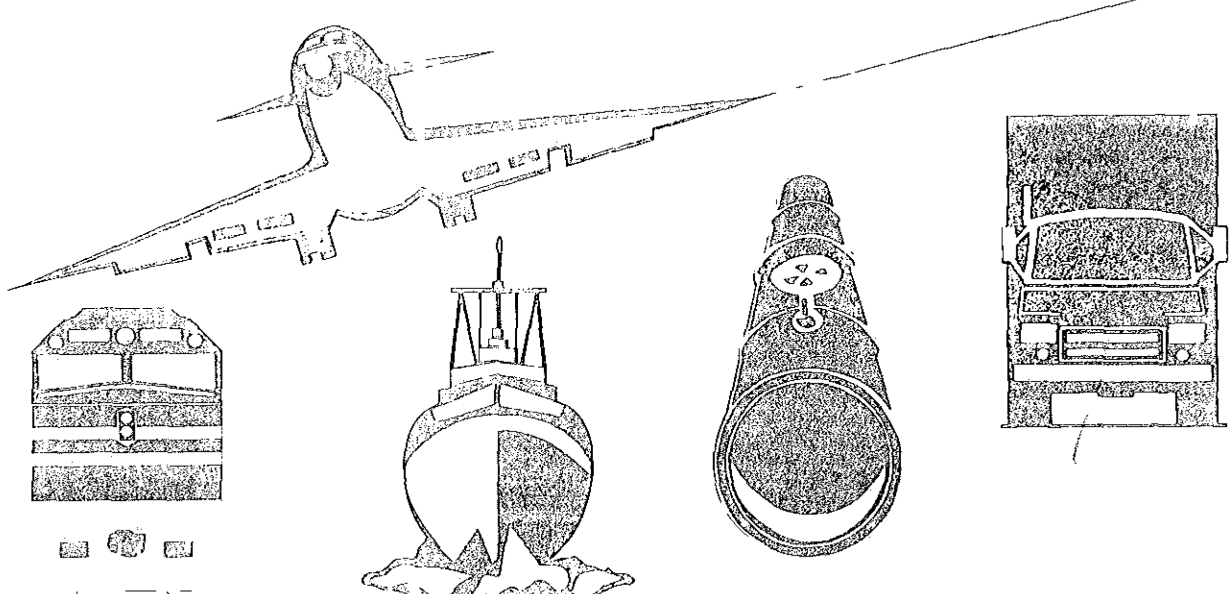
PB90-917007
NTSB/RHR-90/01

TIONAL TRANSPORTATION SAFETY BOARD

RAILROAD/HIGHWAY ACCIDENT REPORT

COLLISION OF AMTRAK PASSENGER TRAIN NO. 708 ON ATCHISON, TOPEKA AND SANTA FE RAILWAY WITH TAB WAREHOUSE AND DISTRIBUTION CO. TRACTOR-SEMITRAILER STOCKTON, CALIFORNIA DECEMBER 19, 1989



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16 Abstract
This report explains the collision of a passenger train with a tractor-semitrailer at a grade crossing in Stockton, California, on December 19, 1989 The safety issues discussed in the report are grade crossing warning devices, standards for lamp bulb voltages for grade crossing warning devices, application of railroad operating rules in fog conditions, truckdriver training for operating in dense fog, emergency communications, and survival factors in passenger cars Safety recommendations addressing these issues were made to the National Railroad Passenger Corporation (Amtrak), the TAB Warehouse and Distribution Company, the Atchison, Topeka and Santa Fe Railway Company, the Federal Highway Administration, the California Department of Transportation, the California Public Utilities Commission, the Federal Railroad Administration, the Association of American Railroads, the American Short Line Railroad Association, and the Members of the General Code of Operating Rules Committee

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EXECUTIVE SUMMARY

About 9:38 a.m., Pacific standard time, on December 19, 1989, National Railroad Passenger Corporation (Amtrak) passenger train 708, consisting of one locomotive unit and five passenger cars, struck a TAB Warehouse & Distribution Company tractor semitrailer in a dense fog at a highway grade crossing near Stockton, California. The collision derailed the locomotive and all five passenger cars. A fire followed the train impact with the truck.

The grade crossing had flashing lights and gates that were functioning at the time of the accident. The engineer, fireman, and truckdriver were killed in the collision and fire. Three of the 7 train crewmembers and 49 of the 150 passengers were injured. The total estimated damage was $2,435,000.

The National Transportation Safety Board determines the probable cause of this accident was the failure of the truckdriver to operate his vehicle at a speed consistent with the dense fog and to stop at the lowered grade crossing gate.

The major safety issues in the accident include:

- Grade crossing warning devices where sight distances are frequently reduced by fog.
- Standards for lamp bulb voltages for grade crossing warning devices.
- Truckdriver awareness and training for operating in dense fog.
- Inability of on-board train personnel to communicate with dispatcher in emergencies.
- Survival factors in passenger cars concerning the adequacy of seatlocks, the securement of food service equipment, the performance of luggage restraints, and the passengers' inability to exit through the vestibule doors.

Recommendations concerning these issues were made to National Railroad Passenger Corporation, Atchison, Topeka and Santa Fe Railway Company, Federal Highway Administration, California Department of Transportation, California Public Utilities Commission, TAB Warehouse & Distribution Company, California Trucking Association, and Federal Railroad Administration.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

COLLISION OF AMTRAK PASSENGER TRAIN NO. 708 ON ATCHISON, TOPEKA AND SANTA FE RAILWAY WITH TAB WAREHOUSE AND DISTRIBUTION COMPANY TRACTOR SEMITRAILER STOCKTON, CALIFORNIA DECEMBER 19, 1989

INVESTIGATION

The Accident

On the morning of December 19, 1989, National Railroad Passenger Corporation (Amtrak) train 708, consisting of a one unit locomotive and five Amfleet III (Horizon) passenger cars, was eastbound from Oakland, California, en route to Bakersfield, California, on the tracks of the Southern Pacific Transportation Company (SP) and the Atchison, Topeka and Santa Fe Railway (ATSF). (See figure 1.)

The conductor testified at the Safety Board deposition proceedings[1] that before departing Oakland the engineer and he reviewed their track warrants and bulletins; however, nothing was provided that informed them about the fog in the San Joaquin Valley. Nevertheless they discussed the fog that would be encountered in the San Joaquin Valley as the conductor had previously heard a weather report about the fog conditions on his car radio while en route to Oakland. Train 708 departed Oakland about 0725.[2]

The conductor stated that it was a "routine trip...until shortly after Stockton." Regular station stops were made at Richmond, Martinez, and Antioch for passengers. Delays did occur at these stops because of the holiday passenger traffic.

About 48 miles west of Stockton a dense fog was encountered as train 708 entered the San Joaquin Valley near Martinez. However, the conductor stated that the fog caused no operational delay of the train and "that particular fog condition didn't warrant...in my opinion, a slowing of the speed of the train."

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[1] See appendix A.

[2] All times are local time, Pacific standard time, and based on the 24-hour clock.

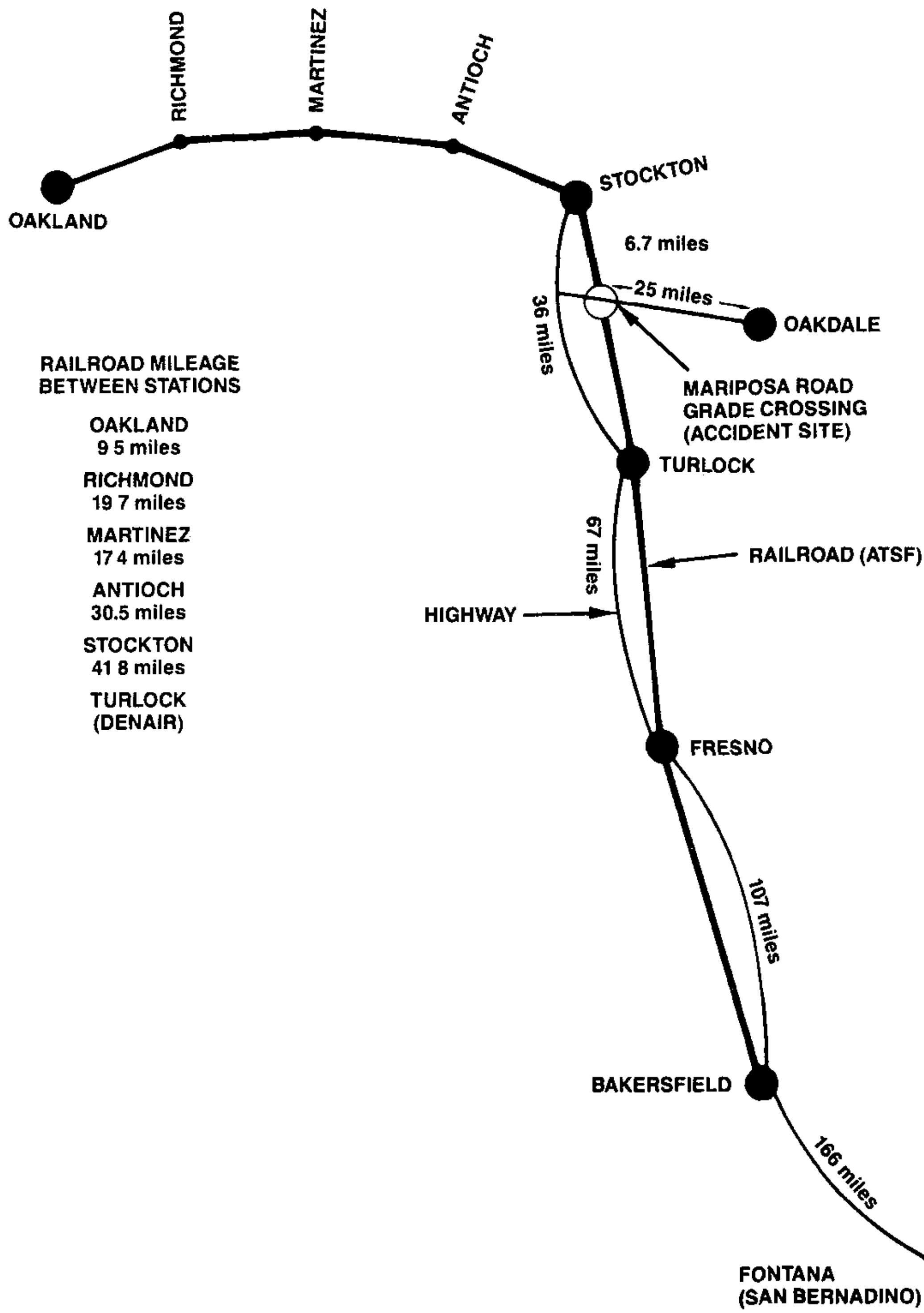

Figure 1.--Diagram of Amtrak Train 708 route beween route between Oakland and Bakersfield and TAB Tractor semitrailer between Fontana and Stockton/Oakdale.

Train 708 arrived in a dense fog at Stockton about 15 minutes late at 0924. While train 708 was in the Stockton station, Amtrak train 711, operating westbound from Bakersfield to Oakland, arrived on an adjacent track, but could not enter the station until train 708 cleared the platform. The engineer of train 711 stated that he stopped his locomotive beside the locomotive of train 708 and talked with the train 708 crew. The engineer of train 711 stated that they discussed "how bad the fog was" and the "terrible" weather conditions.

Train 708 departed Stockton with about 150 passengers; no departure time was reported. The conductor estimated that the train was travelling about 70 mph toward the Mariposa Road[3] grade crossing about 6 miles (geographically) southeast of Stockton. Both the conductor and assistant conductor stated that they heard the locomotive horn warning signal for the grade crossing. The assistant conductor, who was standing in the aisle of the second coach, stated that within "15 to 20 seconds" after the warning signal for the crossing he felt the train brakes "go into emergency and everything lurched forward...no more than 2 seconds later there was an impact" and the train derailed.

As the train approached the grade crossing from the west, a tractor semitrailer (truck) owned and operated by the TAB Warehouse & Distribution Company (TAB) of Fontana, California, was approaching the crossing from the east. The truck was en route to Stockton from Oakdale. The truck entered the crossing from the east. (See figure 2.) The trailer (van) was loaded with boxes of 1-pound cans of chocolate syrup. The driver was the only occupant of the truck.

The locomotive struck the truck and sheared off about 15 feet of the van front causing its contents to be dispersed over the ground and into the interior and onto the exterior of the locomotive and the first two passenger cars. Two persons in another truck witnessed the collision. These witnesses stated that they had been following the accident truck for about 3 miles "probably two and a half truck lengths behind him." The driver of the witness truck stated "we came up on the crossing, and all at once I caught a glance of the train out of the corner of my eye." They also stated that at the time of the collision their visibility was about 150 feet and the gates and lights were not working. However, the engineer of train 711 stated that when his train had passed through the crossing area about 30 minutes earlier his visibility had been about one car length (about 85 feet) and the grade crossing warning devices were working.

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[3]Mariposa Road is a two lane undivided east-west paved road designated as San Joaquin County Road J7. The grade crossing has automatic gates, wayside flashing lights, cantilevered flashing lights, a bell, and standard highway advance warning signs.

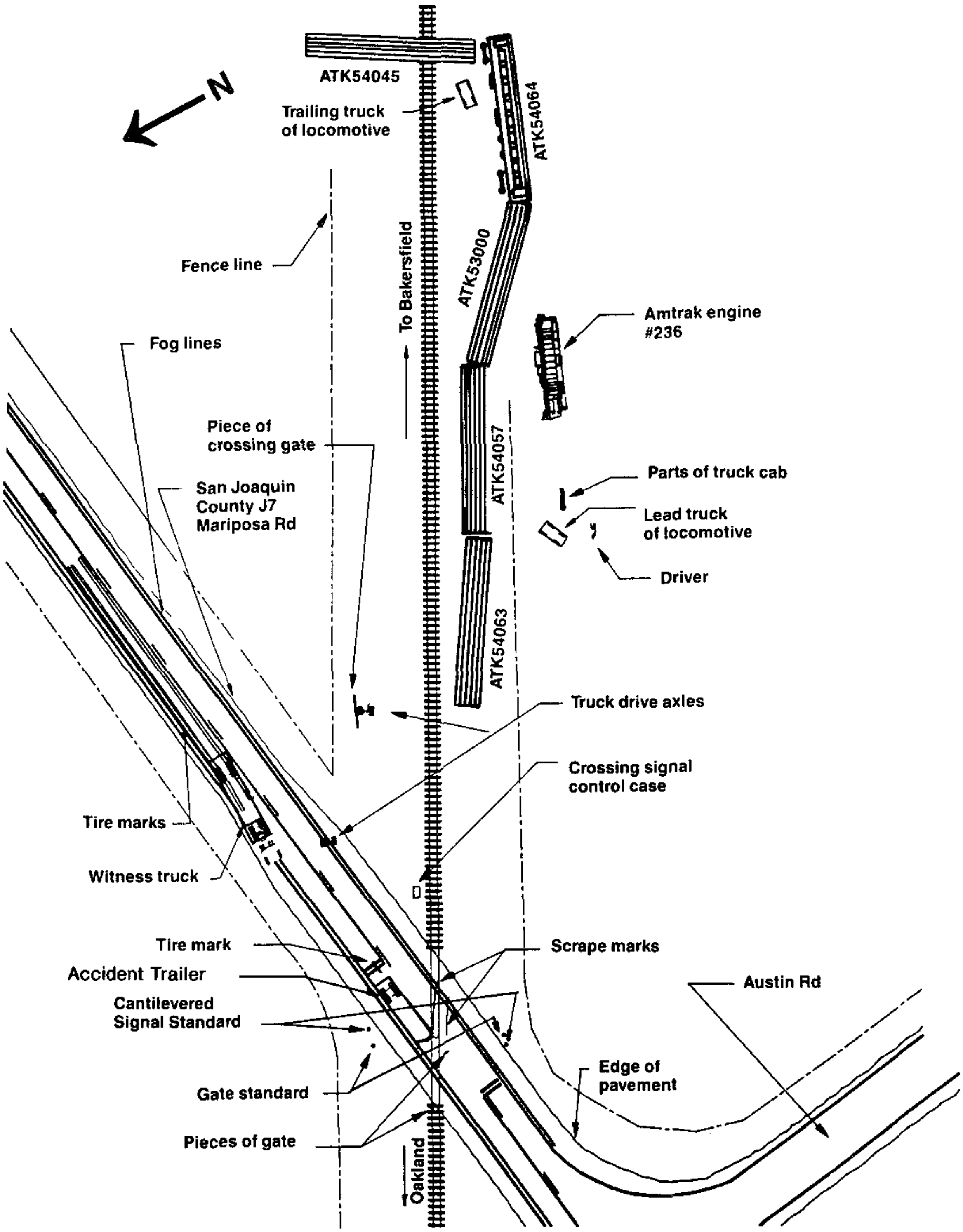

Figure 2--Diagram of crossing/derailment site.

The collision derailed the locomotive and all five passenger cars. A fire ensued after the train collided with the truck. The accident truck left tire marks about 6 feet long about 50 feet from the crossing. The train came to rest about 480 feet east of the crossing. The engineer, fireman, and truckdriver were killed in the collision and fire. The body of the engineer was found on the ground adjacent to the locomotive, and the body of the fireman was found in the locomotive cab. The tractor and the front section of the semitrailer were destroyed and scattered about the crossing area. The body of the truckdriver was found about 250 feet east of the crossing.

Emergency Response

The California Highway Patrol (CHP) Stockton area communications center received a telephone call from a resident near the accident scene at 0938. CHP immediately dispatched personnel[4] and requested assistance from the Stockton Police Department. CHP assumed overall command of the accident site.

The Stockton police received an accident report call on the 911 emergency notification telephone line, immediately transferred the call to the Stockton Fire Department (SFD), and advised the San Joaquin County communications center. Nine local fire departments were dispatched between 0940 and 1014. Six ambulances from Stockton and five ambulances from the county were also dispatched to the accident scene. The accident occurred in the Collegeville Volunteer Fire Department district, which was the first responders to arrive on scene at 0958. All other dispatched units were on scene by 1043.

When the SFD arrived they established a joint incident command system (ICS) of fire suppression and rescue activities with the CHP assigned the role of incident command. The SFD immediate response to extinguish the burning locomotive was to use water only from a single 1 1/2-inch hand line. The fire was fed by diesel fuel that had escaped from the ruptured locomotive fuel tank. The diesel fuel pooled in and under the locomotive that was lying in a depression adjacent to the track. Because the seat of the fire was inaccessible, the use of water proved ineffective, and an aqueous film forming foam agent was then used. The fire was extinguished in about 2 1/2 hours.

The emergency medical and rescue activities used ambulance paramedics and firefighters. Uninjured and slightly injured (ambulatory) passengers were taken to a building near the accident scene for identification and triage. Passenger identification was necessary since train 708 was an unreserved train and had no passenger manifest available. The injured were transported to five area hospitals. The three fatalities were taken to the morgue by the San Joaquin County coroner.

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[4]The CHP Multidisciplinary Accident Investigation Team (MAIT) assisted in the investigation by locating various items of evidence and providing laboratory test information.

Both the City of Stockton and San Joaquin County disaster plans were implemented in response to the accident. When the accident occurred, many of the county's fire chiefs were attending an ICS training class about 5 miles from the accident. The training instructor began the class with a scenario of a train accident that happened near the actual accident site.

On January 4, 1990, agencies that had participated in the emergency response held a critique and debriefing session. They discussed problem areas involving the training and limited experience in the ICS, the availability of ICS identification vests, and the initial radio incompatibility experienced. These problems were considered minor and were resolved during the on-scene response activities. The critique session resulted in the decision of the San Joaquin County Office of Emergency Services (OES) to implement the State OES California On-Scene Coordination Frequency (CALCORD) for use by all county agencies. The CALCORD enables fire, police, emergency service personnel, and other affiliated agencies to have a common on-scene VHF frequency to assist in using the ICS.

Injuries

Injuries	Amtrak Employees	Passengers	Truck	Total
Fatal	2	0	1	3
Serious	1	7	0	8
Minor	2	42	0	44
None	2	101*	0	103
Total	7	150*	1	158

*Estimate provided by Amtrak.

Train Information

General--Train 708 is one of six daily passenger trains operated on the San Joaquin route between Oakland and Bakersfield, California. The service is financed in part through funds made available by the California Department of Transportation (CALTRANS). On December 19, 1989, train 708 was in this order: a single locomotive unit, two coaches, one food service car (half-dinette, half-coach), and two coaches.

The locomotive was a single 3,000 horsepower, diesel-electric passenger unit, type F-40-PH, manufactured by the Electro-Motive Division of the General Motors Corporation. The unit was equipped with 26L brake equipment, a Barco speed recorder, and a Nathan five-chime air horn/whistle. The locomotive had an 1,800 gallon diesel fuel tank and a 243 gallon lube oil tank. The A-1 pilot charging cut-off valve was removed for testing to the Westinghouse Air Brake facility in Vacaville, California, and the Safety Board laboratory in Washington, D.C., to determine whether the engineer or a trainline separation applied the train's emergency brakes.

The Horizon passenger equipment was making its second round-trip in revenue service on the San Joaquin route. The passenger equipment is part of the new Horizon fleet of 104 cars built for Amtrak by Bombardier, Inc., of Boucherville, Quebec, Canada.[5] The Horizon car bodies are based upon a Pullman Company design.[6] The entire car body and exterior sheathing is aluminum, except for the steel underframe structure and collision posts. The underframe structure consists of the center sill, cross-bearers, floor members, and end underframe assembly. Each car weighs about 116,500 pounds. Amtrak's assistant chief mechanical officer (ACMO) told Safety Board investigators that stainless steel equipment of a similar design weighs about 104,000 pounds. Amtrak stated that the major weight difference is because of the type of truck used on the equipment.

The Horizon cars have airbrake equipment to control the airbrake operation. The system performs all train braking functions pneumatically without electrical application. The Horizon cars have "H" type tightlock couplers.

On December 22, 1989, a full-service brake test was made on all cars (except coach AMTK 54045 which had substantial underframe damage). Safety Board investigators observed the movement of the brake cylinder piston on each car, but could not observe the actual brake application on any car because of the damage to the truck mounted brake components.

Depending on the car configuration, the coach cars provide seating for 77 to 82 passengers, and the food service car provides seating for 49 to 51 passengers. All seats are double width (double occupancy) with an armrest at the end of each seat. Seating units are mounted on a lower frame that is supported at the side frame and by a pedestal at the aisle and can be locked into position to face either forward or rearward. The seat units unlock by depressing a pedal at the top of the pedestal and rotating the seat unit to the alternate facing position until it snaps into the locked position. All seats and seatlocks in the Horizon equipment are manufactured by Coach and Car.[7]

Overhead luggage shelves about 2 feet wide are located along the sidewalls over the seating areas. Luggage restraints are provided that are made of square metal tubing extended about 4 inches above the shelf and fastened along the length of the overhead shelf lip. Vertical dividers, also of square metal tubing, are spaced about every 10 feet on the overhead

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[5] The coaches were delivered to Amtrak in November 1989, and the food service car was delivered in July 1989.

[6] Bombardier, Inc., obtained the Pullman design when it purchased Pullman Technology, Inc., in 1986.

[7] Coach and Car is the manufacturer and supplier of the seating units used in Amtrak's Amfleet II and Horizon equipment See appendix C for Coach and Car seatlock mechanism design.

shelves. At the car ends are storage shelves that can also be used for luggage storage; no luggage restraints are provided for these shelves.

Passenger entrance to the interior of a car is through a side vestibule door. Amtrak's ACMO stated to Safety Board investigators that the Horizon cars have a latch located at the upper interior corner of the vestibule door to "prevent, particularly, children from opening the door while the train was in motion...we [Amtrak] have nullified the access from the exterior of the car." The Amtrak officer also stated that no thought was given to providing an outside latch to correspond with the inside latch that would have allowed outside entrance since "we took the design from the Amfleet [passenger cars]...we had no problems...and they had been running for 7 or 8 years."

Damages--In the derailment the locomotive unit (#236) separated from the passenger cars and turned 180 degrees coming to rest on the fireman (left) side in a trackside ditch. (See figure 2.) The cab compartment and nose of the locomotive suffered collision damage. The roof of the cab was displaced downward so that the top of the windshield opening was just above hood level. Both windshield halves and side glass had been displaced from their original position. The interior sustained extensive fire damage both in the cab and engine room compartments. The fire damaged all gauges, control valves, and relays, as well as consuming the Barco speed recorder paper tape. The trucks separated from the locomotive in the derailment resulting in extensive damage to the truck frames, bearings, and traction motors. (See figure 3.)

The five passenger cars derailed at varying angles. The first car, coach AMTK 54045, sustained the most severe damage. (See figure 4.) This car separated from the locomotive and the second car. It came to rest in an upright position at right angles to the track with a large gaping hole in the right side of its trailing end. The second car, coach AMTK 54064, came to rest on its side. It was separated from, but in line with, the third car. The third, fourth, and fifth cars (AMTK 53000, AMTK 54057, and AMTK 54063) derailed in generally an upright position and did not separate. The second through fifth cars had minor interior and exterior damage to safety appliances, truck frames, and aluminum car bodies. Amtrak determined that the damage to #236 and AMTK 54045 was so severe that they would not be repaired.

About 1,400 feet of track was damaged. The prefabricated timber plank crossing received only minor damage. The westbound traffic crossing gate arm was broken. A section of the crossing gate arm and the attached red warning lights had been broken from the crossing gate arm. The signal instrument case including its contents of control equipment was also damaged.

Vehicle Information

General--The truck was owned and operated by TAB Warehouse & Distribution Company of Fontana, California. The vehicle specification data sheet showed a combination weight of 33,390 pounds as the truck's empty weight. The load of chocolate syrup weighed 44,730 pounds.

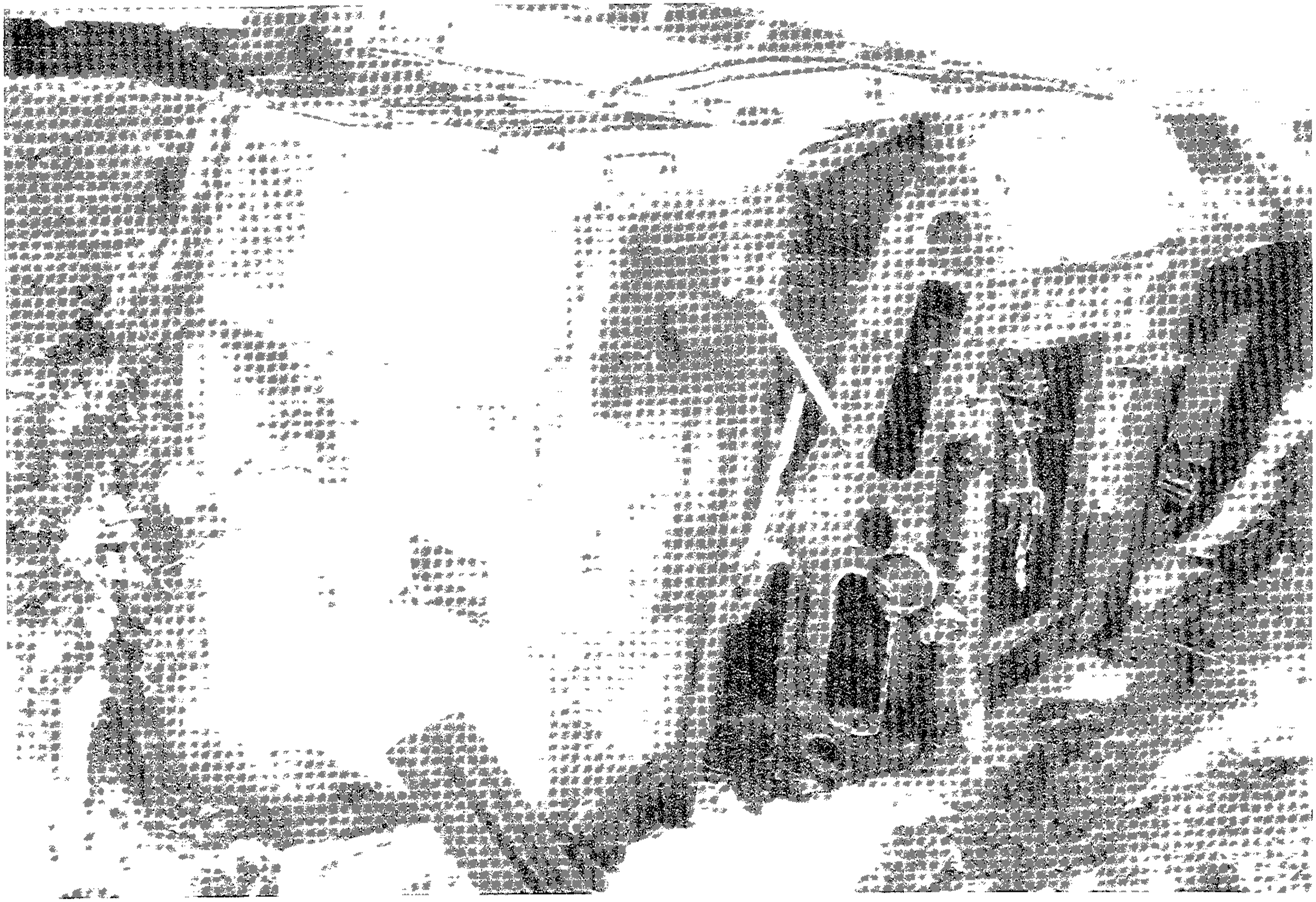

Figure 3--Front end of locomotive of train 708.

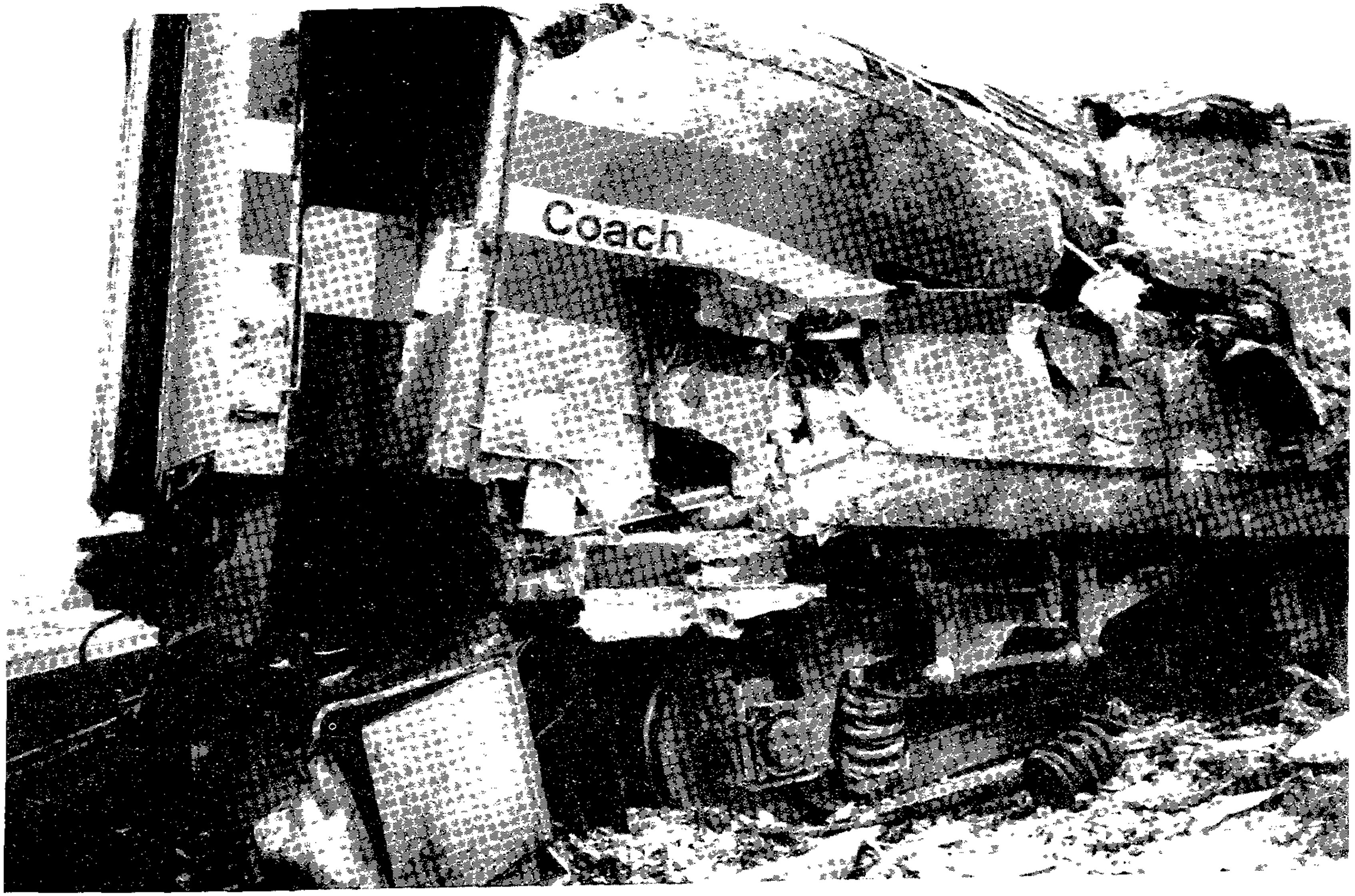

Figure 4--Side damage to Amtrak 54045.

Tractor--The three axle cab-over-engine tractor was manufactured in 1983 by the General Motors Corporation. It was equipped with power steering, a sleeper, a 350-horsepower 6-cylinder Cummins diesel engine, a Fuller Roadranger RT 12610 10-speed transmission, and two 150-gallon fueltanks. The maximum speed for the combination vehicle according to calculations based on tire size, engine rpm, transmission gears, and drive axle ratio was 72 mph at 2100 rpm.

Semitrailer--The semitrailer was a 1987 model refrigerated van 48 feet long and 102 inches wide manufactured by Pullman Trailmobile. The total length of the tractor-semitrailer combination was 58 feet 7 inches.

Postaccident inspection showed that both the tractor and trailer were equipped with a standard four spring suspension system, air-mechanical service brakes, and radial tires on all axles. Tread depth varied from 8/32 inch to 18/32 inch (Federal and State minimum is 2/32 inch). Tire air pressure varied from 80 to 90 psi (rated pressure is 85 to 95 psi) for the tires that held air. All trailer tires still had air in them as did three of the eight tires on the drive axles (five were deflated). Tires on the steering axle were destroyed in the accident. The brake pushrod travel was measured on all axles except the steering axle due to its extensive damage. Measurements varied from 1 3/8 inch to 1/2 inch. Manufacturers recommend that brakes with type 30 chambers, as on this vehicle, be adjusted when the pushrod travel reaches 2 inches. The brake linings on the combination vehicle varied from 10/32 inch to 23/32 inch (Federal and State minimum is 1/4 inch). The last maintenance on the tractor was on December 12, 1989, when a dash light was repaired, a headlamp was replaced, the rear differential was adjusted, and oil was added. Preventive maintenance on the semitrailer was on November 28, 1989.

Damages--The tractor was destroyed in the collision. The burned steering wheel, brake and accelerator pedals, and one door were separated and impacted against the front of the locomotive. (See figure 3.) All three of the tractor axles were separated from the chassis, and both 150-gallon fuel tanks were separated and ruptured. No evidence of burning was found on the fuel tanks. Both countershafts from the main transmission gear box had broken teeth on the second and fifth gears. Visual examination of the rear tractor lamps indicated that both the running lights and braking lamp filaments showed stretching and deformation.

The front 15 feet of the 48-foot trailer was destroyed. The braking lamp filaments from the trailer showed no signs of any deformation.

Train and Vehicle Damage Estimate

Amtrak, ATSF, and TAB provided the following estimate of damages based on replacement costs:

Railroad equipment	$ 2,225,000
Railroad track/signals	$ 80,000
Truck and load	$ 130,000
Total	$ 2,435,000

Train Crew and On-Board Service Personnel Information

The train crew consisted of an engineer, fireman, conductor, and assistant conductor.[8] The on-board service personnel consisted of three Amtrak employees. Although these employees had previous railroad experience they had not worked together on a regular basis. The train crew had operated over this territory before; however, train 708 was a new assignment for each crewmember.[9]

The Amtrak crew register showed that the crewmembers had all reported for work about 0655 on the morning of the accident. Each had been off duty from about 12 hours 50 minutes (fireman) to about 32 hours 16 minutes (assistant conductor). The on-board service personnel reported for work about 0500.

Amtrak personnel records showed that the engineer, fireman, conductor, and assistant conductor were qualified on the General Code of Operating Rules (GCOR) and their examination dates were current. Amtrak officers stated during the investigation that the on-board service personnel had participated in several emergency procedure training classes. These included an orientation at the time the new Horizon passenger cars were put in service. The service attendant who was seriously injured in the accident stated that the last training class she attended was about 5 months before the accident.

The company medical records for the train crewmembers showed no evidence of medical problems.

Truckdriver Information

The truckdriver[10] was an employee of TAB and had an assigned delivery schedule that included locations on the Fontana/Stockton/Oakdale route. He had a valid California driver license authorizing him to operate the type of equipment involved in the accident. In 1983 he had passed both a Department of Transportation exam on Motor Carrier Safety Regulations and an over-the-road driving skills test. He was certified again in 1989 with a second written exam and road test because of the Federal commercial drivers license law adopted by California for a commercial drivers license. A review of his California driving record showed four offenses since 1987: three moving violations for exceeding the 55-mph maximum speed limit for a tractor

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[8]See appendix B for more detailed personnel information.

[9]Amtrak initiated a third San Joaquin daily train (train 708/709) for service beginning December 17, 1989, using the new Horizon passenger equipment.

[10]See appendix B for more detailed personnel information.

semitrailer and one log book violation for exceeding the hours of service provisions for duty.

The truckdriver had been off work from 1245 on Saturday, December 16, 1989, until he reported to Fontana about 2300 on Monday, December 18, 1989. His activities on those days is unknown. His roommate reported that the truckdriver went to bed Sunday evening and was still asleep at 0500. His company medical records showed no evidence of medical problems.

Accident Site Information

The railroad between Stockton and the accident site is situated geographically in about a north to south direction, but for ATSF train movement operations it was considered as an eastbound and westbound direction respectively.[11] Mariposa Road crossed the single track of the ATSF at grade in an east/west geographic direction. The railroad location for the Mariposa Road grade crossing is milepost (MP) 1114.7, California Division, Stockton Subdivision.

Track, Wayside, and Crossing Signals--The single main track was designated as Class 5 track according to the Federal Railroad Administration (FRA) Track Safety Standards. Although FRA Class 5 track permits 90 mph for passenger trains and 80 mph for freight trains, the ATSF authorized timetable speed was 79 mph and 55 mph respectively.[12] The track is straight for at least 2 miles on either side of the grade crossing. The track gradient is .1 percent ascending for eastbound trains approaching the grade crossing. A whistle post, which designates the point a train must begin sounding a crossing warning signal, is located 1,967 feet in advance of the crossing for eastbound train movements.

A Centralized Traffic Control (CTC) system controls the wayside signals and track switches that the dispatcher operates through a computer-assisted control machine located in San Bernadino, California. The computer records all controlled signal and track switch changes at designated control points. The computer record for the movement of train 708 on the day of the accident indicated that train 708 entered a control point located 7,309 feet west of the east end of Walnut siding[13] at 09:34:45 and entered the interlocking control point at 09:35:49 moving eastbound towards Mariposa Road.

In 1948 back-to-back mast mounted automatic flashing light signals were installed at the Mariposa Road grade crossing. In 1973 two cantilevered mounted automatic flashing light signals with bells and automatic gate mechanisms with 27-foot 6-inch gate arms and lights were added to the

[11]Although the accident site was located 6 miles geographically south of Stockton, its railroad location would be considered east of Stockton.

[12]ATSF System Timetable No. 1, effective Sunday, October 29, 1989, California Division, Stockton Subdivision, Special Instruction Number 1.

[13]The east end of Walnut siding is about MP 1116

existing warning devices to accommodate a widening of the highway. The mast and cantilevered mounted flashing lights were 25-watt 10-volt lamp bulbs with 8 3/8-inch and 12-inch red roundels (lens) respectively. The warning system was controlled by direct current (d.c.) track circuits and a "Harmon model 1140-B" motion detector.[14]

The Mariposa Road crossing warning system was designed to activate to provide the motorist with an advance warning time of 32 seconds for eastbound trains and 28 seconds for westbound trains when the trains are operating at 79 mph. The crossing warning system will activate when an eastbound train enters the start circuit 3,724 feet west of the crossing or a westbound train enters the start circuit 3,237 feet east of the crossing. When a train enters the start circuit the crossing warning system lights begin to flash, and the pedestrian bells ring. About 3 seconds after activation, the gates begin their descent which takes an additional 14 seconds. It took 17 seconds for both gate arms of the crossing warning system to move from the vertical to horizontal position.

The Federal Highway Administration (FHWA) "Manual On Uniform Traffic Control Devices (MUTCD)," Section 8C-5, "Train Detection," states that circuits controlling automatic flashing light signals shall provide for a minimum operation of 20 seconds before the arrival of a train. The California Public Utilities Commission (CPUC) regulations, provided by California General Order No. 75-C, govern the protection of grade crossings. These require crossing signals be activated for about 25 seconds, with limits of from 20 to 30 seconds, in advance of the fastest train normally operated over the protected crossing.

A monthly inspection of the crossing control circuits and components was made on December 13, 1989, in accordance with ATSF Instructions I-70. No exceptions were noted on this inspection or the previous three monthly inspections. No Federal regulations govern the operation, inspection, or maintenance practices for railroad-highway grade crossings.

A postaccident inspection of the crossing gate arm and gate mechanism on the morning of December 19, 1989, found that the gate arm of the westbound traffic lane of Mariposa Road had been broken. Broken pieces of the gate arm were found mixed with debris from the truck and in the crossing flangeway. A 16-foot section of the gate arm was located near one of the tractor axles about 160 feet south of the crossing. Fragments of loose pulverized glass, similar in appearance to the pulverized glass from the windshield of the truck, were found on top of the gate mechanism housing and the crossing arm base support.

During the CHP accident investigation they recovered a 1 3/4-inch piece of red translucent plastic about 1/8 inch thick with irregular shaped edges

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[14]The electronic motion detector provides an electronic track circuit which automatically deactivates highway crossing warning devices when a train is stopped or reverses direction while on the approach circuit to the crossing.

from the mud which had accumulated in front of the derailed locomotive following the collision. The CHP examination report of their investigation showed that CHP found: a plastic lens that had a concave surface comprised of parallel curved ridges and a convex surface which had a smooth finished pattern of hemispherical cells of different sizes, a physical comparison to match the plastic lens with the mating edge of the lens that was suspended from the east crossing arm was unsuccessful, and the plastic lens matched the crossing arm light lens in thickness, curvature, concave surface pattern, convex surface pattern, color, and translucence. A GE 18w 10v sig lamp was removed from the end of the east crossing gate arm and tested by the CHP. The report showed that the lamp filament was stretched and coiled about itself. In its evaluation of the physical evidence CHP concluded that "the crossing gates and warning system were functioning at the time of the collision."

The signal instrument case housing the crossing control equipment was struck and moved from its support in the accident. When the CHP evidence seal was removed from the signal instrument case housing and opened Safety Board investigators observed that the impact had displaced, broken, and damaged relays. The XR relay that controlled both the lowering and raising of the crossing gates had been overturned causing its front contacts to close. When the front contacts are closed the crossing warning system is deactivated. When the visual inspection was completed, the XR relay was righted, and the crossing warning system was activated; however, the broken gate only lowered to a 45-degree angle. After the contact closure of the XR relay was manually inverted the crossing warning system was deactivated and the gates returned to their full vertical position in 6 seconds. The Harmon 1140-B motion detector was removed for off-site testing at the supplier's facility by the Safety Board.

Highway--Mariposa Road crosses the track from east to west. The single track grade crossing is level, and the crossing angle is about 36 degrees. The track and roadway surface is about 10 feet above the adjacent farmland providing motorists approaching the crossing with an unobstructed view of the track. The centerline of the roadway on both sides of the crossing was a dashed-yellow painted line for eastbound traffic and a solid yellow painted no-passing stripe for westbound traffic. The edges of the travel lanes were delineated with double-white painted lines (fog lines), with paved shoulders 7.7 feet wide on the north side and 9 feet wide on the south side. The roadway width at the crossing is 42 feet. The posted speed limit for westbound traffic approaching the crossing was 55 mph. A curve advisory sign of 50 mph was located 538 feet east of the crossing for the curve beginning on the west side of the crossing. The roadway approach east of the crossing is straight for about 1/2 mile. It is level for about 500 feet from the crossing where it rises maintaining about a .31-percent gradient to the crossing and then descends at about a .86-percent gradient.

In accordance with the CALTRANS Traffic Manual[15] and the FHWA-MUTCD,[16] the grade crossing traffic control devices included a railroad advance warning sign and roadway pavement markings in addition to the automatic flashing lights and gates. The standard (W10-1) railroad advance warning sign (yellow 36-inch-diameter sign with a black "X" and the letters "RR") was mounted on a post on the north side of the roadway about 766 feet east of the grade crossing. The westbound roadway pavement markings consisted of a white stopping line painted on the roadway surface about 51 feet from the track and a painted white "X" with the letters "RR" on the westbound roadway surface extending from about 635 feet to 685 feet from the track.

The MUTCD, Section 2C-3, "Placement of Warning Signs," provides a "Guide for Advance Warning Sign Placement Distance." The guide recommends a minimum distance of 700 feet for a railroad advance warning sign for a highway posted for 55 mph and when conditions require "a higher driver judgement...which requires the driver to use extra time in making and executing a decision." The MUTCD recommends this distance for a 10-second reaction time.

In the postaccident inspection of the roadway surface, two dual-tire marks about 133 feet long were measured in the westbound lane. These ended near the final stopped position of the witness truck. A single faint tire mark beginning 14 feet from the final resting position of the rear dual tires of the accident truck and 6 feet long was also located on the westbound lane. It crossed both of the white stop lines and ended near the left rear side of the accident semitrailer. The CHP had measured a single faint tire mark about 67 feet long. This tire mark began 128 feet behind the stopped position of the rear tires of the accident trailer. This mark was not visible later when Safety Board investigators inspected the roadway surface. At the time of the accident the CHP reported that the roadway surface was wet from the fog.

San Joaquin County provided traffic count data and an accident history for the Mariposa Road grade crossing. The most recent traffic count (June 1989) resulted in an ADT (average daily traffic) count of 5,786 vehicles. The accident history showed three injury accidents; one before 1962, another in August 1970, and a fatal accident on October 24, 1989.

Railroad Operations

General--Train 708 originated at Oakland and moved over the SP tracks to Port Chicago, California, a distance of about 35.5 miles, where it entered onto ATSF trackage. Train movements on the ATSF are governed by the General Code of Operating Rules (GCOR) and ATSF Timetable No. 1 with its

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[15] California Department of Transportation Traffic Manual, Chapter 4, "Signs," and Chapter 6, "Pavement Markings."

[16] Federal Highway Administration "Manual On Uniform Traffic Control Devices," Section 8B-3, "Railroad Advance Warning Signs," and Section 8B-4 "Pavement Markings."

special instructions (both effective Sunday, October 29, 1989). The crewmembers of train 708 had received track warrants and track bulletins at Oakland. The track warrant authority for movement over the ATSF was issued by radio from the dispatcher. Six track bulletins were in effect on the ATSF; however, none applied to the territory between Stockton and the point of the accident.

Rule 101 of the GCOR states:

> PRECAUTIONS ACCOUNT UNUSUAL CONDITIONS: Trains and engines must be protected against any known condition which may interfere with their safety.
>
> When conditions exist which may impair visibility or affect condition of track or structure, speed must be regulated to ensure safe passage and to ensure observance and compliance with signal indications.

According to Amtrak and ATSF officials in the absence of other instructions, application of the rule is left up to the judgment of the individual engineer or conductor, or both. The conductor of train 708 stated, "If we [train crew] can see what the signals are, then we just go with the maximum authorized speed for the train at the particular locations we pass through during our trip...[the fog] wasn't unusually heavy, and in my opinion a reduction in the speed of the train wasn't warranted." Amtrak and ATSF officials agreed with the conductor's interpretation of rule 101.

Rule 15 of the GCOR states that a succession of short sounds from the locomotive horn was to be used when an emergency existed. On approaching a public crossing at grade the operation of the locomotive horn was to be sounded "sufficiently in advance to afford warning, but not less than a quarter mile before reaching the crossing...and prolonged or repeated until the crossing is occupied by the engine." Two long sounds followed by a short sound then another long sound were to be made.

Communications--Following the accident the conductor attempted to notify the ATSF dispatcher with his portable radio, but was unsuccessful; however, his emergency radio transmission was overheard by westbound ATSF freight train 189-16 which was in the Stockton yard. The crew of train 189-16 in turn contacted the operator at the Stockton tower and the ATSF dispatcher in San Bernardino advising of the train 708 emergency. At the same time the dispatcher became aware of a problem with train 708 from the CTC display, he received the emergency message being relayed by the Stockton operator. He then instructed the Stockton operator to request emergency assistance. The taped recording of the dispatcher radio recorded the emergency notification from train 189-16 at 09:37:30.

Two separate systems make up the radio operations. With the first, referred to as "point to train," the train crew in the locomotive communicates with the dispatcher using the locomotive cab radio. With the second, referred to as "end to end," the train conductor communicates with the train crew in the locomotive using a hand-held portable radio.

In the "point to train" system a dispatcher has control of several radio base stations in his territory. The distance between base stations could vary from 20 to 100 miles depending on the terrain. The locomotive radio transmitter develops about 35 to 45 watts of radio frequency (RF) power. The radio on train 708 was designed for use on all railroad carriers in the United States, was capable of transmitting and receiving on any of 92 radio channels authorized by the Federal Communications Commission (FCC), and could produce 16 dual tone modulated frequencies and 10 single audio tones. Each tone is a specific electronic signal to initiate communication with a selected radio receiver (for example: dispatcher signalling and station selection).

The portable radio of the "end to end" system has 5 watts of RF power. It does not have the 92 channels and the 26 tone producing capabilities of the locomotive radio.

The FCC assigned a frequency of 160.650 Megahertz to the ATSF. This frequency is used on both the "point to train" and "end to end" systems. The ATSF dispatcher radio receiver has a signalling system whereby the dispatcher's radio receiver would not turn on to receive a message unless a specific single audio tone was transmitted from another radio. Four different audio tones are used to separate the radio system by dispatcher territories. The Stockton subdivision uses a 2600 hertz audio tone. The only employees that have radios with the audio tone capability are engine crews, certain maintenance-of-way personnel, trainmasters, railroad police, and other designated management employees.

Amtrak Oversight--Both Amtrak and ATSF had efficiency testing programs in effect for supervisory personnel to perform efficiency tests in day-to-day operations to ascertain the proficiency of train crews in complying with the operating rules and special instructions. The train crewmembers that operated train 708 on the day of the accident had efficiency tests performed by both Amtrak and ATSF supervisors. Amtrak supervisors had conducted efficiency tests that included personnel of train 708's crew on eight occasions in 1989 on ATSF property and covered 20 ATSF operating rules. No exceptions were noted during these tests. ATSF efficiency test records also showed two tests that included the personnel of train 708's crew were performed with no exceptions noted.

Truck Operations

Examination of the truckdriver's daily records showed that during November and December the workweek usually involved about a 376-mile night trip from Fontana to Stockton, California, sleeping during the day, and returning to Fontana the next night.[17] The schedule began on a Sunday or Monday, two trips a week, with most of the weekend off. The truckdriver's trips usually began about 2300 in Fontana. He would travel to Stockton

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[17] The record showed 10 trips from Stockton to Oakdale during this period. Three of these had taken place after December 6, 1989.

and/or Oakdale to be unloaded and loaded, then travel south about 36 miles to Turlock where he usually arrived around 1200, although he had arrived as early as 0900 and as late as 1500, to sleep. His average driving time was about 10 hours for the 376-mile trip. He would sleep about 8 to 10 hours before leaving Turlock between 1700 and 2300 to drive to Fontana. He was then off for about 16 hours before starting the cycle again. The cycle ended on Friday or Saturday followed by 58 to 67 hours off work.

On Monday, December 18, 1989, the truckdriver reported to work in Fontana about 2300. No record was available indicating when he left, although a TAB employee stated that his usual pattern was to leave about 2330. According to the TAB warehouse foreman the truckdriver had arrived at the Stockton warehouse between 0600 and 0615. The warehouse foreman reported talking with the truckdriver, and the truckdriver said that he had experienced "bad fog from Fresno" and it was "getting worse." The truckdriver left Stockton about 0700. According to the plant security guard's record he arrived at the Oakdale plant about 0806 and left the plant about 0905 to return to Stockton. On the 25-mile trip from the Oakdale plant to Stockton on Mariposa Road the truckdriver encountered four railroad/highway grade crossings (two with flashing lights and gates), one traffic light, and two stop signs (one about 2 miles from the accident site). The TAB dispatcher, who is also a truckdriver, stated that in the past 10 years he had not had to stop for a train at the Mariposa Road grade crossing. Also, he said that the truckdriver involved in the accident was familiar with the route used on the day of the accident; however, it had only became part of his regular route on December 6, 1989.

Operation Lifesaver is a national organization that focuses on grade crossing safety through educational presentations at local schools and public media events. California initiated their Operation Lifesaver Program in 1979, and it is supported by the Office of Traffic Safety, CHP, CALTRANS, and CPUC. The four major railroads also supporting the State program are the Union Pacific, SP, ATSF, and Amtrak. TAB does not participate in Operation Lifesaver, nor do they provide any specialized training for their drivers when they must cope with dense fog.

Meteorological Information

At 0900, December 19, 1989, the Stockton National Weather Service (NWS) issued a special weather statement about the dense fog that had been issued earlier at 0300 by the San Francisco NWS. The weather statement advised that the dense fog continued with visibility dropping to zero in many areas throughout the San Joaquin Valley. The Stockton NWS statement additionally advised motorists to reduce their speed and to be prepared to slow or stop with little or no notice as the visibility could drop to zero with little or no warning.

The lead forecaster and the area manager at the San Francisco NWS office stated to a Safety Board staff meteorologist that the dense fog in the San Joaquin Valley occurs mainly from November through February. According to the NWS personnel the fog that forms in the valley is called Tule fog[18] because of the marshlands where it is the most prevalent. The Tule fog is persistent and can last for several days. Visibility during these episodes varies between 0 and 1/2 mile. The lowest visibility in the fog occurs between 0400 and 1000. In the San Joaquin Valley the most dense fog forms in the Stockton area because of the surface topography and the proximity to rivers. Tule fog episodes end with the passage of fronts that provide strong winds that ventilate the valley.

The NWS issues dense fog advisories when fog is expected to reduce visibility to less than 1/4 mile. The advisories are disseminated over the National Oceanic and Atmospheric Administration (NOAA) Weather Wire Service, the NOAA Weather Radio, and the Family of Services.[19] These services are available to the public.

In December 1989, the NOAA recorded 25 days of fog where the visibility was 1/4 mile or less in the Stockton area. This represented the highest number of days recorded. Historical records show the average number of fog days at Stockton where visibility was 1/4 mile or less for December is 11.4 days.

The following was contained in a Public Information Statement about the Tule fog issued by the San Francisco NWS at 0300 on December 19 which stated:

> The visibility in tule fog is often less than 1/8 of a mile...660 feet...and can be as little as 10 feet or less. Because it forms in the coldest air...the areas where it is the densest are in the bottoms of valleys. Persons traveling through these areas can have visibilities of 1/2 mile or more...then drop into a depression where they can see only a few feet.

The surface weather observation at Stockton at 0855 and 0955, December 19, 1989, reported an indefinite ceiling of 0 feet, sky obscured,[20] visibility of 0 miles, fog, temperature 36 degrees Fahrenheit, and winds between 80 and 120 degrees at 4 knots.

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[18] Technically Tule fog is called radiation fog. A major type of fog that is produced over a land area when radiation cooling reduces the air temperature to or below its dew point. Thus, a strict radiation fog is a nighttime occurrence, although it may begin to form by evening twilight and often does not dissipate until after sunrise.

[19] The NOAA Weather Wire Services, the NOAA Weather Radio, and the Family of Services disseminate weather warnings, forecasts, and data to the mass media and other special users for relay to the public.

[20] The condition when 10/10 of the sky is hidden by surface-based obscuring phenomena such as fog or smoke.

Medical, Pathological, and Toxicological Information

Minor injuries to passengers consisted of a variety of contusions, bruises, and sprains. Serious injuries consisted of a variety of fractures and burns. The assistant conductor was treated and released for multiple contusions and bruises. An on-board service attendant was treated and released for first and second degree burns from the hot liquids spilled from the coffeemakers in the food service car.

An autopsy was performed on the engineer, fireman, and truckdriver at the San Joaquin County forensic pathology facility on December 19, 1989. The cause of death of the engineer and fireman was determined to be "massive thermal burns" and of the truckdriver to be "massive trauma."

Toxicological testing was conducted on the truckdriver, engineer, and fireman involved in the accident. Blood and urine samples were collected by a physician from the San Joaquin County Sheriff-Coroner's Office between 1500 and 1600 on December 19, 1989. Testing was performed through the coroner's office under a contract with Central Valley Toxicology of Clovis, California, for about 150 separate drugs. The results of the tests showed no ethyl alcohol and no common acidic, basis, or neutral drugs detected for any of the three individuals.

Survival Aspects

According to passenger and crew statements they received no warning of the impending accident. They described the first realization as feeling an impact or a sharp deceleration followed immediately by a second impact. Some passengers were thrown against the seat or structure in front of them or onto the floor. No passengers reported being struck by luggage from the overhead luggage shelf. Some passengers stated that their evacuation had been impeded by luggage that had fallen to the floor from storage shelves at the car ends, but it was a minor problem. Three unrestrained 36-cup coffeemakers in the food service car overturned spilling hot liquids on the on-board service attendant. Although attachments were provided for securing a coffeemaker, the 36-cup coffeemakers could not be secured in the existing attachments. The securing attachments were for a "Grimes" type coffeemaker.

After recovering from the impact the conductor and the assistant conductor immediately assisted passengers, both injured and uninjured, in evacuating the train. Passengers had removed emergency windows and jumped to the ground or walked on the side of the overturned car and jumped to the ground. Some passengers evacuated the food service area through a floor-level trash door on the car side while others exited through vestibule doors that were opened by on-board service personnel.

During the investigation the conductor stated that he had worked on other trains in revenue service after the accident and had observed unsecured coffeemakers, a condition he considered unsafe. He also stated that he was unaware of any Amtrak policy specifically requiring coffeemakers be secured in appropriate restraints. If he were to report an unsecured coffeemaker as an unsafe condition, he said he would report it to the assistant transportation manager of Amtrak. However, he had not reported the unsecured coffeemakers in this accident nor those observed in subsequent trips and was not required to do so.

The on-board service attendant injured in the food service car stated that when she reported for duty at Oakland she discovered the food service car did not have a coffeemaker "the wiring was there, where you put the coffee pot, but there was no unit there." She reported the missing coffeemaker and was issued the three 36-cup coffeemakers from the commissary department. The Amtrak ACMO stated that it is a shared responsibility of the mechanical department employees, on-board service personnel, and the conductor to inspect equipment before placing it in service. Amtrak's policy of ensuring that the proper coffeemaker is in place is one of education rather than disciplinary action. The ACMO also stated that they later discovered that the "Grimes" type coffeemaker that should have been in the food service car may have been removed in Chicago by other mechanical department employees before the car was delivered to Oakland for use in revenue service.

A postaccident inspection of the passenger cars was made by CPUC personnel from the Railroad Operations and Safety Section on the afternoon of the accident. The CPUC reported several partially turned seats and luggage on the floor near the vestibule areas. When the passenger cars were inspected by Safety Board investigators the following morning, all seats had been returned to their locked position facing forward, and all luggage had been removed. Except for seat units damaged in the accident in car AMTK 54045, all seat units had operable seat locks.

Tests and Research

Sound Level Tests in Truck Cab--Several on-scene sound tests were conducted using a TAB vehicle similar to the accident vehicle, ATSF yard engine 6389, and westbound train 711. At 40 mph, with the truck windows up the truck's interior sound level measured 79 dbA,[21] with the truck's heater on the sound level increased to 81 dbA, and with the addition of the truck's radio the sound level was 84 dbA. The heater and radio settings in the accident vehicle could not be determined.

The sound level in the truck cab measured 72 dbA when the truck was positioned at 384 feet from the crossing (truck engine at idle and heater operating) and ATSF 6389 was stopped at the whistle board location at 1,967 feet from the crossing. The sound level reading in the truck cab did not change when ATSF 6389 sounded its horn. The sound level in the truck cab was 73 dbA with the truck 217 feet from the crossing and ATSF 6389 sounding its horn at 615 feet from the crossing; with ATSF 6389 at the crossing sounding its horn the sound level in the truck cab was 75 dbA.

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[21] A decibel reading on the "A" scale indicating a numerical expression of the relative loudness of a sound.

Train 711 sounded its horn as it approached the crossing from the east about 10 mph. The truck was positioned about 384 feet from the crossing. During this test the sound level varied from 72 to 73.5 dbA, increasing as the train approached the crossing. Amtrak's specifications for an F-40-PH locomotive electronic horn, as used on both train 708 and 711, require a sound level reading of 114 dbA "directly in front of the locomotive, 100 feet away at above ground height of 48 inches."

Deceleration Tests--A G-Analyst[22] was used to measure the deceleration levels of a similar truck. A test at 25 mph on dry pavement resulted in a reading of .58 g on the G-Analyst when the driver made an emergency stop locking all wheels. A test at 30 mph resulted in .47 g, but all wheels did not lock. A test at 40 mph produced .5 g, but the vehicle pulled to the left, and the driver let up on the braking effort.

Signal Circuit Board Tests--A quality control test was performed on the Harmon 1140-B motion detector unit from the crossing signal case at the Harmon assembly plant in Grain Valley, Missouri, on February 26, 1990. All tests were within Harmon's specifications except for the loss of shunt feature. The loss of shunt feature measures the change in the flow of a d.c. electric current when a train is in the track circuit being measured. The time limits of the timing circuit for the loss of shunt feature had decreased from 13 seconds to 8.5 seconds due to a defective diode.

Metallurgical and Physical Science Tests--The A-1 pilot charging cutoff valve from the locomotive of train 708 was examined at the Vacaville, California, facilities of Westinghouse Air Brake and the Safety Board laboratory in Washington, D.C. The exterior of the valve was found to be blackened with carbon soot and discolored, in the manner typical of fire damage. Disassembly showed that the two internal pistons were free to move in their respective cylinders. An inspection of the O-ring seals found they were hardened and charred consistent with exposure to elevated temperatures. No other information could be developed from the valve.

An on-site visual examination of the trailing locomotive truck of train 708 by a Safety Board investigator found red paint transfers on areas that had metal fragments. Sample metal fragments were collected and submitted to the Safety Board laboratory for chemical analysis. The samples were chemically analyzed with the aid of an x-ray energy dispersive spectrochemical analysis. All samples analyzed contained a large amount of aluminum along with small amounts of other elements.

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[22]A G-Analyst is a three-axis accelerometer built by Valentine Research, Inc., of Cincinnati, Ohio, to measure deceleration levels.

Crossing Timing Circuit Tests--On March 11, 1990, tests were performed by the ATSF, FRA, and CPUC at the Safety Board request to verify the warning time of the Mariposa Road crossing signals for both eastbound and westbound crossing circuits. Train speed was verified with a radar speed measuring device. The results were as follows:

EASTBOUND TRAIN	TIME	SPEED	WARNING TIME (SECONDS)
ATSF 5812	0845	58	39
AMT 708	0958	79	29
AMT 704	1256	79	29

WESTBOUND TRAIN	TIME	SPEED	WARNING TIME (SECONDS)
AMT 711	0904	80	28
ATSF 5157	0909	55	42
ATSF 169	1245	50	44

Highway Grade Crossing Signal Lamp and Illumination Tests--The grade crossing lights are normally powered by a d.c. battery that is continuously being charged from a commercial 110-volt alternating current (a.c.) power source and charging rectifier. The measured d.c. voltage reading on the four lights of each main mast and each cantilevered unit with a.c. power on showed the voltage on the lights varied from 8.5 volts to 9.0 volts for the 16 bulbs. The bulbs were 10-volt 25-watt standard precision signal bulbs. The ATSF signal engineer stated that the minimum is 8.5 volts. According to an Association of American Railroad (AAR) publication[23] lowering the lamp voltage of a 10-volt lamp bulb to 8.5 volts extends the life of that lamp bulb from 350 hours to 2,890 hours. This publication was written for wayside signals; however, the practice of lowering the voltage has also been used for railroad/highway crossing signals to extend lamp bulb life.

The relationship between voltage, beam candlepower,[24] bulb life, and red light transmission was developed for several configurations of flashing light units, different lamp bulb wattage, and different roundels in a 1968 AAR report.[25] For a lamp voltage of 10 volts the output was 100 percent with a beam candlepower of 1,275 and a red light transmission of 5,760 feet. At a lamp voltage of 8.5 volts the output was 66 percent with a beam candlepower of 850 and a red light transmission of 3,801 feet. In addition to reducing the light transmission, reducing the lamp voltage may cause the observed lens

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[23] American Railway Signaling Principles and Practices, Chapter XIII, Light Signals and Light Signal Lamps

[24] Beam candlepower is the luminous intensity of a light source (beam) expressed in candela which is 1/60 of the luminous intensity of 1 square centimeter of a radiating body at the temperature of solidification of platinum.

[25] Report of the Ad-Hoc Committee D--Highway Grade Crossing Protection.

color to darken because the lamp filament changes color and brightness. To meet the light transmittance standards of the AAR[26] the light source must be at or near its maximum voltage. The Safety Board attempted to determine if any research had been done about the light transmission of signal crossing devices in fog. It contacted several signal crossing device manufacturers and found that research for light transmission in fog is too difficult to evaluate as fog density is so variable.

Several Class I railroads have written instructions stating that the minimum lamp voltage for grade crossing warning lamps is 9 volts. One reported that it instructs the employee to set the lamp voltage at the full rating of 10 volts. There are no Federal rules, regulations, orders, or standards for the safe maintenance, inspection, and testing of signal systems and devices at railroad/highway crossings. Each railroad establishes their own practices. In California the CPUC has the regulatory authority for railroad/highway grade crossings through general order No. 75-C. This order describes the range (300 feet on a clear day, with a bright sun at or near the zenith), the light beam spread, and the number of light flashes per minute.

Passenger Car Seatlocks--During the investigation of an Amtrak accident in Russell, Iowa,[27] Amtrak informed the Safety Board in a letter dated April 1, 1988, that a newly designed seatlock had been developed and dynamically tested and the seatlocks were to be furnished to Amtrak by June 1988 from a new supplier, Trison, Inc. The letter also stated that from 1984, the date the retrofit program began, until April 1, 1988, about 33 percent of the Amtrak fleet of passenger cars had been modified with the latest design seatlock. The Safety Board understood from this correspondence that all cars in the fleet were to receive the new seatlocks. However, as a result of a meeting on March 23, 1990, between the Amtrak ACMO and Safety Board staff, the Safety Board has become aware that this is not the case. The ACMO explained that all cars with seatlocks manufactured by AMI, Inc., will have the seatlocks replaced with seatlocks manufactured by Trison, Inc.; however, cars that have seatlocks manufactured by Coach and Car, such as those on the Horizon equipment of train 708, will not have the seatlocks replaced because Amtrak believes that the Coach and Car seatlocks have performed well in accidents.

During the March 23, 1990, meeting with Amtrak, Safety Board staff and the ACMO examined an Amfleet II coach car that had been made ready for revenue service at Union Station in Washington, D.C. The coach car was equipped with the Coach and Car seatlocks. By visual examination all foot levers of the seatlocks appeared to be in the locked position; however, a

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[26]Association of American Railroads Signal Manual Part 7.1.10 provides chromaticity coordinates and transmittances of roundels for highway crossings.

[27]Railroad Accident Report--"Collision and Derailment of Amtrak Train 6 on the Burlington Northern Railroad, Russell, Iowa, October 12, 1987" (NTSB/RAR-88/04).

physical examination of five randomly selected seats in the coach car resulted in a rotation of the seats. The seats were then rotated to the transverse position and pushed, with moderate effort, toward the wall of the car until the seatlock engaged.

At the same meeting the ACMO said that he would inform each of the superintendents responsible for the day-to-day operation of trains to alert their personnel that Coach and Car seatlocks may not be locked although they appear to be locked. This action was to be followed with a memo to all inspectors responsible for mechanical quality control, reiterating the importance of assuring that seatlocks are fully engaged.

Amtrak provided the Safety Board with the following status of the seatlock retrofit program as of May 21, 1990:

Car Type	Total Fleet	Completed	Remaining
Amfleet I	472	243	229*
Amfleet II	124	124	0
Superliner	150	56	94**
Horizon	93	93	0

* expected completion 1993
** expected completion December 1991

Other Information

The CHP MAIT made several conclusions in their accident report: the accident truckdriver's speed was between 48.6 mph and 51 mph at impact, he saw the railroad crossing warning devices, he made an emergency application of his brakes, but because of the limited sight distance in the dense fog and the speed of the vehicle there was insufficient distance to stop before the railroad tracks, and the truck slid about 128 feet onto the tracks where train 708 struck its right side.

According to the CHP report one of the first CHP officers on scene reported the range of visibility to be "greater than 130 feet and less than 245 feet." CHP determined that the maximum safe speed for the conditions of limited sight distance and stopping capabilities would have been 35 mph. CHP identified two violations by the truckdriver in the report: two counts of Penal Code Section 192 (c) (1) - Vehicular Manslaughter With Gross Negligence, and Section 22350 of the Vehicle Code, exceeding a safe speed for existing traffic, weather, visibility, and roadway conditions.

ANALYSIS

General

No aspects of the track or wayside signal system were a causal factor in the accident. Train 708 was inspected before leaving Oakland, and according to the conductor no mechanical problems were experienced before the accident. The train crewmembers were qualified for their positions and operated train 708 in compliance with the railroad operating rules.

No aspects of the mechanical condition of the TAB truck were a causal factor. The TAB truckdriver was qualified to operate the type of vehicle involved in the accident. The physical and medical condition of the engineer, fireman, and truckdriver were not a factor in this accident. Drugs and alcohol were not a factor in this accident.

The Accident

Train 708 derailed when it collided with a truck in dense fog at a railroad/highway grade crossing that had automatic flashing lights and crossing gates.[28] The Safety Board examined the crossing warning devices, the TAB truck operation, and the adequacy of the crossing warning devices. Other areas examined included the conductor's inability to communicate directly with the train dispatcher, the adequacy of the seatlocks, the securement of food service equipment, the performance of luggage restraints, and the passengers' inability to exit through the vestibule doors.

Crossing Warning Devices

The ATSF computer record for the movement of train 708 indicated that it had taken about 1 minute 4 seconds to travel the 7,309 feet between the control points at Walnut siding before it came to Mariposa Road. Therefore, train 708 was operating at about 78 mph as it approached the crossing circuit for the Mariposa Road grade crossing. At the maximum authorized operating speed of 79 mph the automatic flashing lights were designed to provide motorists with a 32-second warning time of approaching eastbound trains; the FHWA only recommends a minimum of a 20-second warning time, while the CPUC regulations specify a range of 20-30 seconds, in advance of the fastest train normally operated over the crossing. Tests performed on the crossing signal system after the accident showed that the actual warning time was about 29 seconds as measured for two eastbound Amtrak trains operating at about 79 mph. The difference between the designed 32-second warning time and the measured 29-second warning time is a result of test times being made visually using a stop watch and the time it takes (about 3 seconds) for the flashing lights to activate. Thus, the crossing warning device provided more warning time than that recommended by FHWA or specified by CPUC and would have been ample warning time for motorists under normal weather conditions.

Because of witness statements asserting that the crossing warning devices were not working at the time of the accident the Safety Board considered the possibility of its failure. However, the engineer of westbound train 711 stated he had observed the crossing warning devices working when his train went through the crossing about 30 minutes earlier. Also, physical evidence indicated that the system operated properly and within its design parameters at the time of the accident.

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[28] See appendix E for typical gate/cantilevered signal crossing device.

The physical evidence that indicated the crossing gate arms were in the down position at the time of the accident were: the broken pieces of crossing gate arm found in the crossing flangeway; the 16-foot piece of crossing gate arm found 160 feet south of the crossing near one of the tractor axles; the fragments of loose pulverized glass, similar to safety glass from a windshield retained on the shoulder of the crossing arm base; the piece of red plastic lens, matching the characteristics of the lens on the crossing gate arm, found in debris at the front of the derailed locomotive; and the stretched lamp filament from the signal lamp fixture removed from the crossing gate arm. Also, the damage to the crossing signal gate arm is consistent with it being struck by the TAB truck.

The defective diode of the 1140-B motion detector caused the loss of shunt timing to change from 13 seconds to 8.5 seconds. However, had the loss of shunt feature occurred before the accident, it would not have caused the warning system to operate improperly nor have caused the warning to be less than required. This is because the d.c. track circuit provided the proper shunting protection and the motion detector was a secondary device to sense motion. The Safety Board concludes that the motion detector was not a causal factor in the accident.

The crossing gate arms returned to the vertical position following the accident because the XR relay had inverted when the signal instrument case was struck by accident debris. Since the crossing gate arms would have returned to the vertical position in about 6 seconds, the witnesses probably did not see the gates in the down position because the dense fog obstructed their vision. Also, since they were behind the TAB truck, they may not have looked at the crossing gates until after the collision when their truck stopped. Then they saw the gates in the vertical position. The Safety Board concludes the automatic flashing lights were operating and crossing gate arms were in the down position at the time of the accident.

TAB Truck Operation

Tire marks measured at the accident site were characteristic of a nonrotating wheel evident on the pavement resulting in skid marks. The Safety Board determined that the witness truck had been travelling about 44 mph before braking based on the 133-foot skid marks it made.[29] Since the witness truck had been following the TAB truck for the last 3 miles at about 2 1/2 truck lengths, the Safety Board believes that both vehicles were probably travelling about the same speed. At a speed of 44 mph a minimum distance of 261 feet would be required to bring the TAB truck to a stop. This is based on a perception and reaction time of 1.5 seconds and a brake delay time of .5 seconds. The probable limited sight distance in the fog would have increased the time needed to perceive the crossing warning lights, react, and apply the service brakes. Consequently, the minimum stopping distance would have increased proportionally. Had the truckdriver been operating his vehicle at a lower speed, he would have had more time to

[29] See appendix D for vehicle speed/distance calculations.

perceive and react to the impending danger, as well as required less distance to bring the vehicle to a complete stop. The Safety Board concludes that the speed of the truck combined with the reduced visibility created by dense fog significantly reduced the truckdriver's available reaction time.

For the truckdriver to have arrived at Stockton about 0600 when he left Fontana about 2330 the previous night required an average speed of about 60 mph on his 376-mile trip. He told the warehouse foreman at Stockton that he had experienced "bad fog from Fresno" and it was "getting worse." His speed between Fresno and Stockton (about 103 miles) is unknown. However, if he had slowed down in the fog, his average speed in the nonfog portion of the trip would have been in excess of 60 mph. His previous driving violations as well as the speed from Fontana to Stockton indicate a propensity to exceed the legal limits. For the 25-mile trip from Oakdale to the accident site at Mariposa Road, the truckdriver averaged about 50 mph in fog. As discussed earlier the safe vehicle speed based on the sight distance in the existing fog would have been about 29 mph or less; therefore, the truckdriver's operation of his truck from Oakdale to Mariposa Road again indicates a propensity to speed.

Dense Tule fog reduces visual cues and masks physical features that alert motorists to upcoming conditions requiring driver action. To compensate, a driver in dense fog is forced into a state of readiness to detect what limited features are available. Because of the reduced visibility, alertness and vigilance must be maintained. The truckdriver had driven about 2 hours or longer (depending on his speed) in the dense fog from Fresno to Stockton, about 30 minutes from Stockton to Oakdale, and again about 30 minutes from Oakdale to Mariposa Road. Research into various aspects of human vigilance[30] indicates that performance deteriorates after 30 minutes; however, a break in maintaining attention can serve to abolish a performance decrement. Although the truckdriver had breaks between trip segments, research suggests his ability to maintain vigilance may have declined in the 30-minute drive between Oakdale and Mariposa Road. The Safety Board believes that the truckdriver failed to properly assess his visual range in the dense fog and relate that distance to the stopping capability of his truck.

During his employment the truckdriver had driven in dense fog between Fontana and Stockton that included many trips to Oakdale within the last 6 years. His degree of familiarity with the route may have manifested itself in a complacency for its potential dangers. He may have known the track was there, but had not expected to see a train.

Despite the common existence of dense Tule fog in their service area, TAB Warehouse & Distribution Company does not provide any guidance or training for truckdrivers on how to cope with fog. The accident truckdriver had not received any guidance or training from the company on how to operate his vehicle in dense fog. Participation in Operation Lifesaver can provide

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[30]D. R. Davies and G. S. Tune, Human Vigilance Performance (New York: American Elsevier Publishing Company, 1969).

an opportunity to train truckdrivers in how to cope with fog and to contend with railroad/highway grade crossings. The Safety Board believes that TAB needs to establish, and maintain with supervisory oversight, a structured recurrent training program designed to sustain the performance of its truckdrivers at high standards; include in this program instructions on safe operation in adverse weather conditions, with emphasis on overdriving visual range when operating in dense fog; and participate in Operation Lifesaver to develop and implement a grade crossing awareness training program to alert its truckdrivers to the dangers inherent at railroad/highway grade crossings.

Adequacy of Crossing Warning Devices

As the truckdriver approached the Mariposa Road grade crossing he encountered two passive warning devices. These consisted of a standard railroad advance warning sign and pavement markings indicating that a railroad crossing was ahead. Neither warned if a train was approaching or was within the crossing. The railroad advance warning sign and pavement markings complied with both the Federal and California requirements for traffic control devices. The positioning of these passive warning devices was based on vehicle speeds of about 55 mph providing a 10-second reaction time to allow a driver extra time to make and execute a decision. The only active warning devices of a train approaching or within the crossing were the automatic flashing lights, the lowered crossing gate arm, and the sounding of the locomotive horn.

The Safety Board determined that the truck was about 1,879 feet from the crossing when train 708 activated the crossing warning system. The advance warning signs and pavement markings would only alert the truckdriver that a railroad/highway grade crossing was ahead. However, he either did not see them or he saw them and did not take appropriate action.

The most recent FRA report for grade crossing accident statistics shows that 6,025 grade crossing accidents were reported in 1988 of which 252 occurred in California.[31] The same report showed that 1,882 accidents occurred with weather conditions reported as a causal circumstance and that 82 of these accidents reported fog as the circumstance. The FRA report did not provide information for weather related accidents by State or number of casualties.

During the investigation the Safety Board was advised by the ATSF that they had provided a circuit for use with an advance warning sign at a public grade crossing at a State highway (California 58, Kramer Crossing between Barstow and Boron). The circuitry provided a means for an active advance warning device to be activated upon the approach of a train. The California Department of Transportation installed and maintains the advanced warning

[31] Federal Railroad Administration "Rail-Highway Crossing Accident/Incident and Inventory Bulletin" number 11 published June 1989 for calender year 1988.

system.[32] The installation of an active advance warning device located on, or in place of, the passive advance warning sign provides additional perception/reaction time for the motorist approaching a crossing to take appropriate action. The dense Tule fog that historically occurs in the San Joaquin Valley in winter and may last several days can impair driver visibility and increase the time needed to perceive and react to warning signals. If the Mariposa Road grade crossing advance warning sign had been provided with an active advance warning signal to alert the truckdriver that a train was in the crossing or approaching the crossing, about 766 feet would have been available for him to react and stop before his truck reached the crossing. The Safety Board believes that regulatory agencies should require the use of active warning devices in advance of railroad/highway grade crossings actuated by the railroad crossing warning system where sight distances are frequently reduced by dense fog.

The conductor stated that he heard the engineer sound the required warning signàl for the crossing. This warning signal would have been initiated when train 708 was near the whistle post, at about 1,976 feet from the crossing. Because the sound level tests showed that interior truck noise (79 to 84 dbA) was probably greater than the sound level of the horn (72 dbA) of the approaching locomotive the Safety Board concludes that, due to the road noise and the heater fan in the truck, the truckdriver may not have heard the horn of the approaching train.

In a 1985 Safety Study Report[33] the Safety Board addressed audibility warning systems and recommended to the Federal Railroad Administration:

> R-86-45
>
> Reexamine the standard applicable to a trains audible warning systems and require improvements in the audible warning system's ability to alert motor vehicle drivers to approaching trains.

The FRA responded to this recommendation in a letter dated August 4, 1988, stating that the standards applicable to audible warning systems had been reexamined. The FRA response included the following:

> Alterations in the audible warning system could only be accomplished in one of two ways -- the sound could be louder, or it could be different....
>
> Changing the current sound (pitch, tone, notes ululation, etc.) might at first enhance the devices alerting ability, but would, at the same time and for the same

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[32]The CPUC has the exclusive authority to regulate railroad/highway crossings according to CPUC Code 1201 and 1202.

[33]Safety Study Report--"Passenger/Commuter Trains and Motor Vehicle Collisions at Grade Crossings (1985)" (NTSB/SS-86/04).

> reasons, become less recognizable (or at worst confusing) to the motorist. A train horn is currently recognized as a train horn by most of the public. In the short run, a different alerting sound might catch the attention of the motorist more easily, but it is equally likely to confuse him, prompting him to look for some source other than a train.... Over the longer run, the novelty effect and concomitant alerting ability will wear off, and when the new sound becomes associated with trains, it will be no more effective in alerting the driver than the sound he currently associates with trains. This is precisely the cycle that occurred when steam whistles were replaced by diesel horns....
>
> Experience has taught us that the tolerance of engine crews and the tolerance of communities adjacent to the railroad rights-of-way are limiting factors on carriers' ability to effectively raise the decibel levels of their audible warning whistles....
>
> Requiring louder horns has a clear downside, in that it would almost certainly touch off a strong, negative reaction in the communities adjacent to railroad lines.... The capacity to increase the decibel level of the device is very limited, both by public attitudes and by EPA standards....
>
> We have serious reservations about the workability of this recommendation, and question whether any gain in audibility it produces would be outweighed by the limits on the use of the audible device that would surely follow.

The Safety Board replied to this response in a December 21, 1989, letter stating:

> The FRA response...suggests that the FRA is locked into the current situation and that there is no feasible solution to the inability of the current audible warning systems to alert motor vehicle drivers of approaching trains.
>
> For example, the response discusses the fact that some communities have passed ordinances to ban the use of train horns during certain hours and/or at certain crossings.... In these cases, perhaps there is a need to look at a new and different type of alerting system for certain hours of the day that would alleviate the concerns of the communities but still provide sufficient warning to motorists of an oncoming train. The FRA should also look at the feasibility of eliminating passive grade crossings at particular locations.

> Installation of automatic warning devices at crossings in those areas where ordinances are being passed should be look into in detail, as should all factors that currently are taken into consideration to determine the priority by which passive grade crossings are earmarked for upgrading.

Based on that discussion the Safety Board classified Safety Recommendation R-86-45 as "Open--Unacceptable Action" and asked the FRA to look into the problem of audibility once again.

Since that reply to the FRA, the Safety Board has reviewed the issue of audible warnings at railroad/highway grade crossings. The Safety Board's letter of December 21, 1989, moved the bounds of the recommended action beyond the audibility issue into general grade crossing safety. The Safety Board agrees with the FRA that spending more resources on the audibility issue may not be warranted when compared with other grade crossing projects. The need for the upgrading of crossing warning devices from passive to active devices and from active to automated warning devices is greater than the need for research or other actions related to audible warning systems. Based on this discussion the Safety Board has reclassified Safety Recommendation R-86-45 as "Closed--Reconsidered." However, we encourage the FRA to continue working with the industry, the States, and Operation Lifesaver to enhance the safety of railroad/highway grade crossings.

The adequacy of the crossing warning devices also depends on the light transmission intensity of the flashing lights. Since the lamp voltage was not at its rated maximum voltage, the reduced voltage may have affected the intensity of the flashing lights. The Safety Board is concerned about the effect the dense fog would have had on the light transmission intensity of the flashing lights; however, the Safety Board is unaware of any research on light transmission reduction in fog. Also, since the fog density at the time of the accident is unknown, the Safety Board could not determine from what distance the truckdriver saw the flashing lights or if he ever saw them. Reducing the lamp voltage greatly diminishes the brilliance and observed color of the lens, as well as the distance of light transmission and perception. The Safety Board concludes that a motorist's ability to recognize the operating grade crossing flashing lights in dense fog was probably lessened by the reduced lamp voltage.

In the late 1970's the FRA initiated a rulemaking proceeding to address the issue of standards governing the maintenance, inspection, and testing of these devices. The FRA then terminated the rulemaking in 1978 based on the analysis of accident files from 1975 to 1976 that revealed malfunctions were present in only .3 of 1 percent of the cases and testimony failed to make a persuasive case. Rulemaking was done again in 1984, and the FRA reached the same conclusion.

The Rail Safety Improvement Act of 1988, enacted June 22, 1988, directed the FRA to "issue such rules, regulations, orders, and standards as may be necessary to ensure the safe maintenance, inspection, and testing of signal systems and devices at railroad highway grade crossings" within 1 year of the enactment date of the act. To date no determination has been made to issue rules, regulations, orders, or standards. The Safety Board believes that the FRA should at the least promulgate regulations providing for minimum standards for applied lamp bulb voltages for railroad/highway grade crossing warning lights to ensure maximum output, proper color, brilliance, and sight distance.

Communications

The conductor stated that after the accident he could not contact the dispatcher with his portable radio. The dispatcher was notified of the accident when an ATSF freight train crew overheard the conductor's radio transmission and contacted the dispatcher about the accident. The conductor was fortunate that another train was nearby and could relay the emergency transmission. Otherwise, had this occurred in a remote area or where no other train was within the range of the conductor's portable radio, the emergency response would have been substantially delayed. The only radio on a train that had the capability to develop the 35 to 45 watts of transmission RF power and tonal capabilities to communicate with the dispatcher was located in the locomotive cab. In this accident the fire following the derailment destroyed the locomotive, and only the conductor's hand-held 5-watt RF power radio without the tonal capabilities was available. Had the conductor had a portable radio with more RF power and tonal capabilities, he would have been able to communicate directly with the dispatcher. The Safety Board believes that Amtrak should develop and implement a means for the conductor to contact the dispatcher by radio should the locomotive radio be unavailable.

Survival Factors

According to the passenger statements and train crew testimony the initial impact was not severe. At impact passengers were thrown into seats or interior surfaces in front of them, causing some secondary impact injuries. Additional injuries occurred when the second coach, AMTK 54064, turned onto its side.

Safety Board laboratory tests concluded that the metal fragments removed from the trailing truck of the locomotive contained aluminum. These fragments, along with the evidence of red paint transfers similar in color to the paint on the Amtrak equipment, indicate that the first car, AMTK 54045, had been penetrated by the trailing locomotive truck during the derailment. Initially the penetration of AMTK 54045 concerned the Safety Board about the crashworthiness of aluminum covered passenger equipment; however, as no injuries could be linked to the penetration in this accident no conclusion could be made concerning its crashworthiness.

Adequacy of Seatlocks--As seen in this and other railroad passenger car accidents, some passenger seats rotated, and passengers were ejected from their seats. Notwithstanding the damage sustained by the Horizon cars in this accident, no seatlocks failed although some did rotate. In past accidents seat rotation without seatlock failure has been the rule rather than the exception. This may mean that the seats were not fully locked before each accident. The Safety Board concludes that a visual examination of the position of the foot lever on the Coach and Car seatlock is not a conclusive indicator to determine that a seat is actually in the locked position.

In order for a seat that is locked before an accident to unlock and rotate with the seatlock remaining undamaged, the seatlock must encounter an upward vertical force sufficient enough to disengage the latch and subsequently sustain a lateral force that will move the seat inward. Because the probability of a sufficient upward vertical and lateral force to occur that would disengage the latch without damaging the seatlock and move the seats inward would be rather remote, it appears more likely that the seatlocks were not initially engaged. The Safety Board believes that the distribution of a memo is not sufficient and Amtrak needs to establish a systemwide procedure to ensure that all seatlocks are engaged in the locked position before placing equipment in revenue service.

Securement of Food Service Equipment--The Safety Board has observed in previous accidents that unrestrained food service equipment has been ejected from recessed mounts and become injury producing projectiles during a derailment. In its report of the investigation of a 1983 Amtrak derailment at Wilmington, Illinois,[34] the Safety Board recommended that Amtrak:

R-84-40

Correct the identified design deficiencies in the interior features of existing and new passenger cars, which can cause injuries in accidents, including the baggage retention capabilities of overhead luggage racks, inadequately secured seats, and inadequately secured equipment in food service cars.

On March 31, 1985, Amtrak responded that it would enhance securement of food service equipment such as microwave and convection ovens by adding an extra steel bar across the top of the ovens to prevent displacement under extreme shock. The modification was being implemented as food service cars undergo overhaul and 120-day maintenance programs. On July 29, 1985, Amtrak began addressing the issues of seat rotation and inadequately secured equipment in food service cars. However, since they lacked plans to improve the luggage retention capabilities in existing passenger cars, the

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[34]Railroad/Highway Accident Report--"Collision of Amtrak Passenger Train No. 301 on Illinois Central Gulf Railroad with MMS Terminals, Inc., Delivery Truck, Wilmington, Illinois, July 28, 1983" (NTSB/RHR-84/02).

recommendation was classified "Closed--Unacceptable Action." Safety Recommendation R-85-128 was issued on January 15, 1986, addressing the issue of luggage retention devices. Therefore, on March 25, 1986, the Safety Board reclassified Safety Recommendation R-84-40 as "Closed--Unacceptable Action/Superseded."

After an accident in 1987 at Russell, Iowa,[35] involving an Amtrak train the Safety Board made the following recommendation to Amtrak:

> R-88-48
>
> Develop and install effective retention devices for coffeemakers on all passenger cars to prevent them from becoming dislodged in an accident.

Amtrak responded on December 29, 1988, that they had designed and ordered an effective retention device and estimated the new devices would be installed by September 30, 1989. Pending completion of the actual installation Safety Recommendation R-88-48 was classified as "Open-Acceptable Action." Contact with Amtrak staff on September 18, 1990, revealed that the installation of coffeemakers has not been completed. Amtrak informed the Safety Board that this effort had been put on an accelerated schedule with a goal for completion by the end of 1990 (120 days from this staff discussion).

In the food service car in this accident the microwave ovens were held in place with steel brackets that prevented the ovens from coming out of their recessed mounts. However, the coffeemakers were unsecured in the food service car, and the service attendant was injured when the car derailed, the coffeemakers overturned, and hot liquids spilled on her. Although there were attachments for securing a coffeemaker, the attachments were for a different type of coffeemaker, a "Grimes" type coffeemaker, and the replacement 36-cup coffeemakers could not be secured in the existing attachments.

The food service car attendant noted that when the car was being prepared for service in Oakland no coffeemakers were in the car and the replacement coffeemakers supplied by the commissary personnel were the wrong type coffeemakers. According to Amtrak the responsibility to ensure that the proper coffeemakers are in place and secured is shared by the mechanical department personnel, on-board service personnel, and the train conductor. However, while it may be proper for Amtrak's policy to take an educational tack to ensure employee compliance, it can only confuse affected personnel when no clearly defined line of accountability exists. The Safety Board believes that such procedures would not be tolerated in the mechanical or operational aspects of preparing a train and a crew for service. These aspects are perceived as safety related and required, while passenger service

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[35] Railroad Accident Report--"Collision and Derailment of Amtrak Train 6 on the Burlington Northern Railroad, Russell, Iowa, October, 12, 1987" (NTSB/RAR-88/04).

items such as coffeemakers are seen as convenience items related and not necessarily associated with safety. This accident and the resulting injuries show the inadequacy of treating passenger services with any less safety related importance than is shown with the operational and mechanical aspects.

The conductor had stated that he had worked on other trains in revenue service since the accident and had observed unsecured coffeemakers. Since he was unaware of any Amtrak policy that specifically required securing coffeemakers in their appropriate restraints he had not reported the unsecured coffeemakers in the food service car in this accident nor any he observed in subsequent trips. The Safety Board believes that Amtrak should establish systemwide rules to ensure that only properly secured appliances are used in revenue service and establish procedures for enforcing those rules.

Luggage Retention--No passengers reported being struck by luggage stowed in the overhead luggage racks. The Safety Board has previously addressed luggage retention devices and recommended to Amtrak:[36]

R-85-128

> Develop and install effective retention devices in its overhead luggage racks to prevent the dislodging of luggage and other articles in a collision and/or derailment.

The status of this recommendation is "Open--Unacceptable Action."

Safety Board investigators observed during a visit to an Amtrak facility in October 1986 that it appeared the prototype luggage restraint would prevent longitudinal movement of luggage; however, the full effectiveness of the devices for lateral luggage restraint had not yet been evaluated by Amtrak (no evaluation of the luggage restraint performance when a car is rotated from the vertical position). Amtrak believes that the performance of the retention devices in the Stockton, California, and Batavia, Iowa[37] accidents precludes the need for further testing. In this accident, several cars derailed, one overturned, and one came to rest leaning at about a 45-degree angle. According to the CPUC documentation of the interior of the passenger cars immediately following the accident, all luggage was restrained in the overhead racks. Although the luggage restraints may have kept luggage in the overhead racks in this accident, the Safety Board cannot conclude that the amount of luggage placed in these racks is representative of a typical situation on Amtrak trains.

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[36]Railroad Accident Report--"Derailment of Amtrak Passenger Train No. 60, the Montrealer, on the Central Vermont Railway near Essex Junction, Vermont, July 7, 1984" (NTSB/RAR-85/14).

[37]Derailment of Amtrak Train 6 on Burlington Northern Railroad in Batavia, Iowa, on April 23, 1990.

Contact with Amtrak staff on September 18, 1990, revealed that about 60 percent of the affected cars had been retrofitted with the new luggage retention devices. The Safety Board investigation of the Batavia, Iowa, accident is continuing. Although the Stockton, California, accident may not have been a typical situation as the amount of luggage was less than normal and the Safety Board investigators did not observe the position of the luggage after the accident, the Safety Board agrees that the reported performance of retention devices and the rate of retrofit completion warrants an "Open--Acceptable Response" for Safety Recommendation R-85-128.

The only luggage displaced during the accident apparently was from the end of car open luggage storage shelves that lacked luggage restraints. (See figure 5.) Although some passengers complained that the luggage in the aisle slowed their evacuation, they considered it a minor problem. Nevertheless, all items of mass should be secured so they do not injure passengers and do not impede evacuations. The Safety Board believes that Amtrak should modify the luggage storage areas at the ends of Horizon cars to adequately retain luggage in a collision or derailment.

Vestibule Doors--The Safety Board had found in its investigation of an Amtrak passenger train accident in Seabrook, Maryland, on June 9, 1978,[38] that the failure to provide identification of the emergency door release mechanism and to train crewmembers to use the device caused a delay in the removal of injured passengers. Consequently, the Safety Board recommended to the Federal Railroad Administration:

> R-79-39
>
> Promulgate regulations requiring that the emergency release mechanism for doors on passenger-carrying cars be clearly identified so that the doors can be opened easily by passengers in an emergency.

The FRA replied on April 4, 1984, that they have been responsive to the Safety Board recommendations pertaining to rail passenger operations relating to crashworthiness, interior design, and emergency procedures by developing a comprehensive passenger safety program. Safety Recommendation R-79-39 was placed in a "Closed--Superseded" status on July 29, 1985, when the following recommendation was issued after an Amtrak passenger train accident in Gibson, California, on June 23, 1982:[39]

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[38] Railroad Accident Report--"Rear End Collision of Conrail Commuter Train No. 400 and Amtrak Passenger Train No. 60, Seabrook, Maryland, June 9, 1978" (NTSB-RAR-79-3).

[39] Railroad Accident Report--"Fire Onboard Amtrak Passenger Train No. 11, Coast Starlight, Gibson, California, June 23, 1982" (NTSB-RAR-83-03).

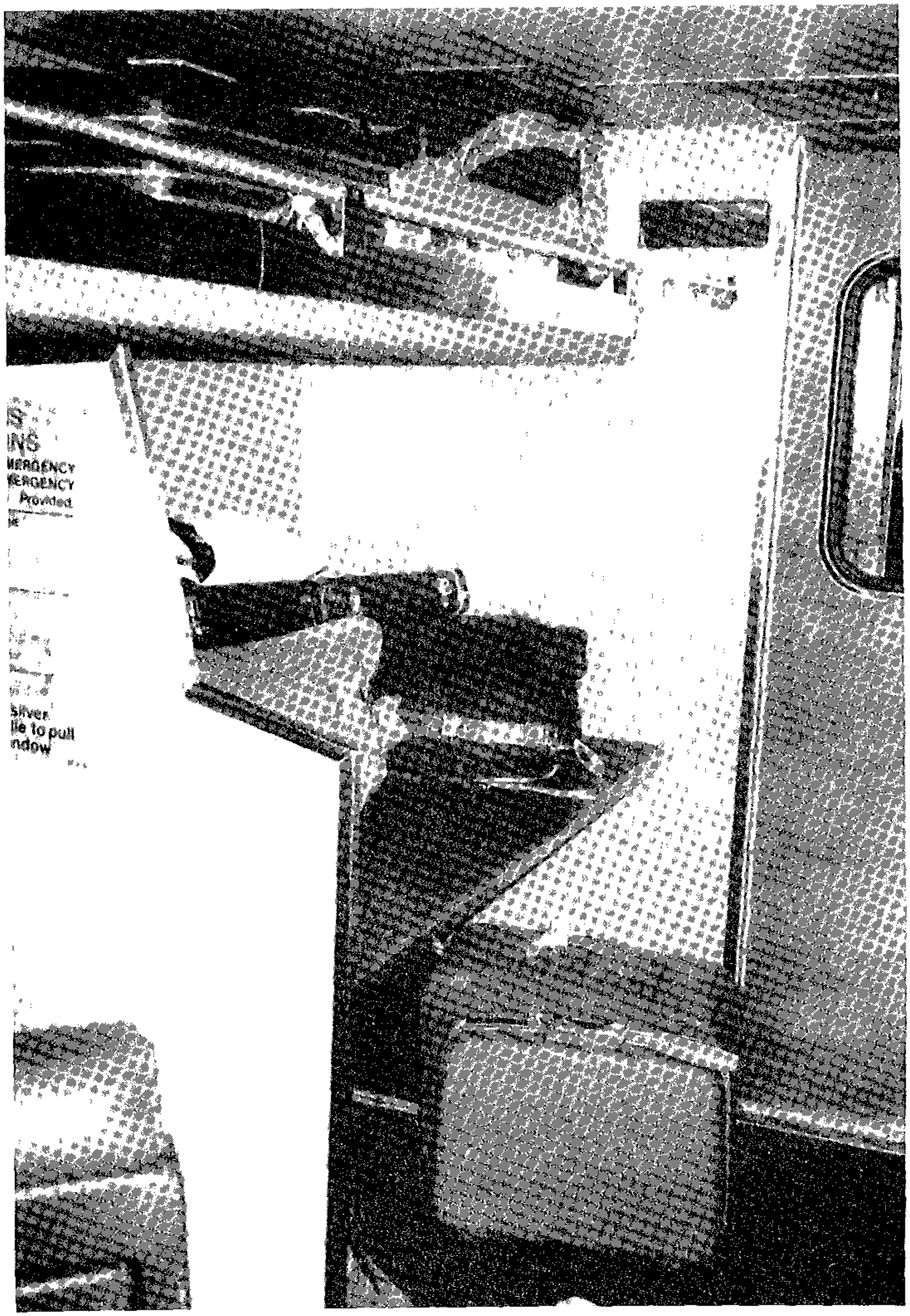


Figure 5--End of car luggage shelf.

R-83-76

Expedite the development of passenger car safety standards which were mandated by Congress in October 1980 (reiterated January 14, 1983), including in the standards:

(a) Criteria for the location and intensity of emergency lights within the cars to assure adequate visibility for escape from smoke filled cars;

(b) Requirements for emergency evacuation plans, for training of personnel for emergencies, and for emergency systems, such as emergency exits and doors, smoke detector systems, etc., specifying the numbers, type, locations, and markings;

(c) Acceptable levels of flame spread rate, smoke emissions, and toxic fumes for interior materials; and

(d) Requirements for the installation of sprinkler system to which water can be supplied by emergency equipment through externally mounted standard standpipes.

The FRA responded on October 8, 1985, that passenger operations had compiled an excellent safety record and a major Federal regulatory effort was not necessary or warranted. Safety Recommendation R-83-76 was placed in a "Closed--Unacceptable Action" status on January 14, 1986.

The vestibule doors of the new Horizon equipment can only be opened from the inside. No method or device is provided to open the doors from the outside. A pawl latch, located at the top of the door inside the car, to open the vestibule door is not clearly marked; the latch must be manually disengaged from inside to open the door for exiting the car. Unless a passenger can determine how to operate the door latch to open the vestibule door, uninjured or ambulatory passengers must either wait for on-board service personnel to open the door to exit to ground level, or they must remove emergency windows, as was done in this accident, to exit the car and jump to the ground, risking injury. The absence of visible interior markings and operating instructions at the vestibule doors may have contributed to the decision made by some passengers to exit the cars by removing emergency windows instead of exiting directly to the ground from the cars that were derailed in the upright position. The Safety Board questions the Amtrak decision to install vestibule door locking devices without clear instructions for opening the doors in an emergency and to nullify the access from the outside to the interior of the new Horizon cars.

When a car has derailed in an upright position, nothing should prevent passengers from opening the vestibule door, providing the door is not jammed or obstructed, once they have located the pawl latch. Furthermore, when a car is in the upright position passengers encounter less risk when they can exit the car directly to the ground through the vestibule door. The Safety Board believes that Amtrak needs to provide visible interior markings and operating instructions at vestibule doors of all passenger equipment that cannot be opened from the exterior of the car.

CONCLUSIONS

Findings

1. No anomalies or deficiencies were evident in the track structure, track geometry, wayside signal system, or in the condition of the automatic brakes of train 708 that contributed to the accident.

2. No evident mechanical deficiencies of the TAB truck were found that contributed to the accident.

3. The automatic flashing lights were operating, and the crossing gate arms were in the down position at the time of the accident.

4. The speed of the TAB truck combined with the dense fog substantially reduced the available reaction time, and the TAB truckdriver failed to bring his vehicle to a safe stop. Also, the TAB truckdriver probably did not see or hear train 708 as it approached the grade crossing.

5. The TAB truckdriver had not received any guidance or training from TAB Warehouse & Distribution Company on the need to regulate his vehicle speed in dense fog.

6. The dense Tule fog in the San Joaquin Valley limited visibility and reduced the effectiveness of the grade crossing warning devices.

7. The reduced lamp voltage from its rated voltage may have diminished the brilliance and the observed color of the lens, as well as the distance of light transmission and perception.

8. No Federal rules, regulations, or orders have been established for providing minimum standards for applied lamp bulb voltages for railroad/highway grade crossing warning lights to ensure maximum output, proper color, brilliance, and sight distance.

9. The conductor's portable radio was insufficient to allow him to communicate directly with the dispatcher.

10. The rotated seats in the passenger cars were probably not a result of failed seatlocks; the seatlocks were probably not fully engaged in the locked position when the equipment was readied for service.

11. A procedure for enforcing systemwide rules to ensure that only properly secured appliances are used in revenue service probably could have prevented the coffeemaker from spilling its contents on the service attendant in the derailment.

12. Had the luggage storage shelves at the ends of the Horizon cars been equipped with luggage restraints, luggage may not have fallen into the aisle slowing passenger evacuation.

13. The absence of visible interior markings and operating instructions at the vestibule doors may have contributed to the passengers' decision to remove emergency windows to exit the cars instead of exiting directly to the ground from the cars that were derailed in the upright position.

Probable Cause

The National Transportation Safety Board determines the probable cause of this accident was the failure of the truckdriver to operate his vehicle at a speed consistent with the dense fog and to stop at the lowered grade crossing gate.

RECOMMENDATIONS

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

--to the National Railroad Passenger Corporation:

Develop and implement a means for the conductor to contact a dispatcher by radio should the locomotive radio be unavailable. (Class II, Priority Action) (R-90-45)

Provide visible interior markings and operating instructions at vestibule doors of all passenger equipment that cannot be opened from the exterior of the car. (Class II, Priority Action) (R-90-46)

Modify the luggage storage areas at the ends of Horizon cars to retain luggage in a collision or derailment. (Class II, Priority Action) (R-90-47)

Establish systemwide rules to ensure that only properly secured appliances are used in revenue service and to establish procedures for enforcing those rules. (Class II, Priority Action) (R-90-48)

Establish systemwide procedures to ensure that all seatlocks are engaged in the locked position before offering the equipment for revenue service. (Class II, Priority Action) (R-90-49)

--to the Atchison, Topeka and Santa Fe Railway Company:

Cooperate with the California Department of Transportation and the California Public Utilities Commission for the installation of active warning devices in advance of railroad/highway grade crossings actuated by the railroad crossing warning system where sight distances are frequently reduced by dense fog. (Class II, Priority Action) (R-90-50)

--to the Federal Highway Administration:

Revise the Manual of Uniform Traffic Control Devices to require the use of active warning devices in advance of railroad/highway grade crossings actuated by the railroad crossing warning system where sight distances are frequently reduced by dense fog. (Class II, Priority Action) (H-90-92)

--to the California Department of Transportation:

Require and install active warning devices in advance of all new and existing railroad/highway grade crossings actuated by the railroad crossing warning system where sight distances are frequently reduced by dense fog. (Class II, Priority Action) (H-90-93)

--to the California Public Utilities Commission:

Require the use of active warning devices in advance of railroad/highway grade crossings actuated by the railroad crossing warning system where sight distances are frequently reduced by dense fog. (Class II, Priority Action) (R-90-52)

--to the TAB Warehouse & Distribution Company:

Establish, and maintain with supervisory oversight, a structured recurrent training program designed to sustain the performance of its drivers at high standards; include in this program instructions on safe operation in adverse weather conditions, with emphasis on overdriving visual range when operating in dense fog. (Class II, Priority Action) (H-90-94)

Participate in Operation Lifesaver to develop and implement a grade crossing awareness training program to instruct its truckdrivers in the dangers at railroad/highway grade crossings. (Class II, Priority Action) (H-90-95)

--to the California Trucking Association:

Establish, and maintain with supervisory oversight, a structured recurrent training program designed to sustain the performance of truckdrivers at high standards; include in this program instructions on safe operation in adverse weather conditions, with emphasis on overdriving visual range when operating in dense fog. (Class II, Priority Action) (H-90-96)

Participate in Operation Lifesaver to develop and implement a grade crossing awareness training program to instruct truckdrivers in the dangers at railroad/highway grade crossings. (Class II, Priority Action) (H-90-97)

--to the Federal Railroad Administration:

Promulgate regulations providing for minimum standards for applied lamp bulb voltages for railroad/highway grade crossing warning lights to ensure optimum rated output, proper color, brilliance, and sight distance. (Class II, Priority Action) (R-90-51)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan M. Coughlin
Vice Chairman

/s/ Jim Burnett
Member

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

Adopted: October 23, 1990

APPENDIXES

APPENDIX A

INVESTIGATION

Investigation

The National Transportation Safety Board was notified at 2:08 p.m., eastern standard time, on December 19, 1989, of a collision and derailment of an Amtrak passenger train with a truck at a grade crossing in Stockton, California. The collision was reported to have resulted in a fire and several fatalities. The investigator-in-charge and other members of the investigating team were dispatched from Washington, D.C., and field offices in Chicago, Illinois; Seattle, Washington; and Fort Worth, Texas. Committees for operations, mechanical, highway, signals/track, survival factors, and human performance were established for conducting the investigation.

The Safety Board was assisted in the investigation by the Federal Railroad Administration, National Railroad Passenger Corporation, Atchison, Topeka and Santa Fe Railway, State of California, Brotherhood of Locomotive Engineers, United Transportation Union, Bombardier, Inc., and TAB Warehouse & Distribution Company.

Hearing/Deposition

The Safety Board staff conducted a deposition proceeding as part of its investigation of this accident on February 28 and March 1, 1990, at Stockton, California. Nine witnesses provided testimony.

APPENDIX B

PERSONNEL INFORMATION

Engineer

Engineer Edward McMillion, age 48, had 21 years of railroad experience. The Southern Pacific Transportation Company hired him on June 23, 1968. He was promoted to engineer in 1972. He remained with the Southern Pacific until being hired by Amtrak in November 6, 1986. He took and successfully completed his last rules exam on November 23, 1988. His personnel record showed no entries for previous operating rules violations. Medical records indicated he was in good health. His distant vision was 20/50 uncorrected and 20/20 corrected. His blood pressure was 150/94 in 1988. He was prescribed the medication Tenormin and/or Furosemide for this condition.

Fireman

Fireman Michael Passarella, age 41, was employed by the Southern Pacific Transportation Company from April 1976 until September 1986 when he accepted a "buy-out" and left the railroad. He was hired by Amtrak July 27, 1988, as an assistant conductor, but he transferred to the fireman position in September 1988. He successfully completed his last rules exam on August 17, 1988. His personnel record showed no entries for previous operating rules violations. Medical records indicated he was in good health. His distant vision was 20/25 uncorrected.

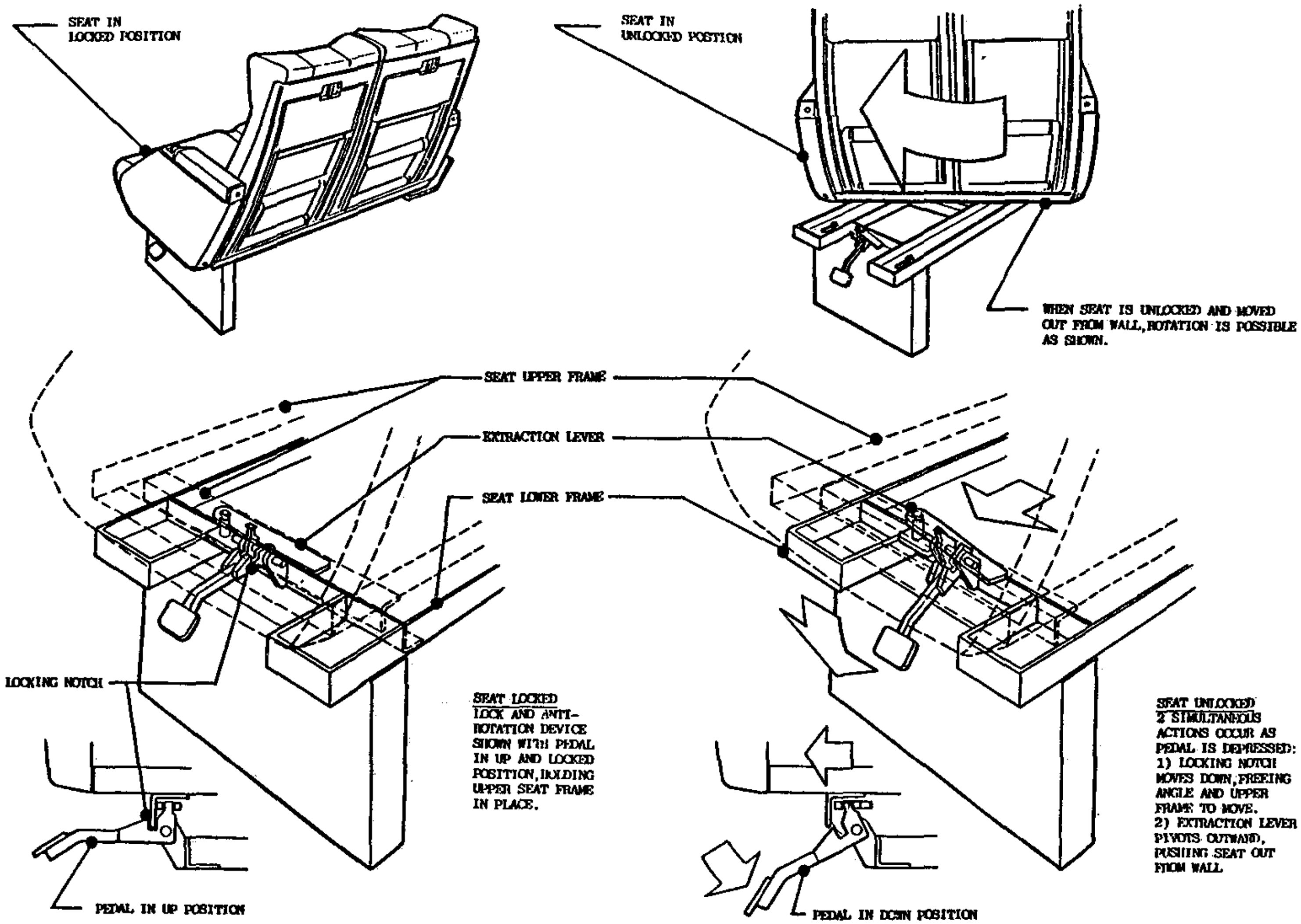
Conductor

Conductor Gary Burke, age 35, began working with the Atchison, Topeka and Santa Fe Railway Company in 1974 as a brakeman before his promotion to conductor in 1984. In November 1986 he was hired by Amtrak. He completed his last rules exam on November 3, 1988. His personnel record showed no entries for previous operating rules violations. His last railroad physical showed he was in good health. His distant vision was 20/20 uncorrected.

Truckdriver

Truckdriver David Haskell, age 47, had been a truckdriver since 1967, first as a local and cross-country truckdriver with Consolidated Freightways and then with three other trucking companies between 1968 and 1983. He had been a manager and dispatcher, as well as an owner-operator. His personnel file contains notations from various companies that he was a "good man" and "loyal-reliable." In 1983 he began work with the TAB Warehouse & Distribution Company. At that time he passed the Department of Transportation exam on Motor Carrier Safety Regulations and the over-the-road driving skills test. He was recertified in 1989. His company medical exams showed he was in good health. His distant vision was 20/20 uncorrected. His driving record showed four violations: three for exceeding the 55-mph maximum speed limit for a tractor trailer and one for exceeding the hours of service requirements.

COACH AND CAR SEATLOCK MECHANISM



APPENDIX D

VEHICLE SPEED/DISTANCE CALCULATIONS

Speed of Trucks Before Accident

The following formula was used to calculate the speed before braking for the following truck:

$$V_i = (V_e^2 - 2 \times a \times d)^{1/2}$$

where V_i = initial velocity in feet per second (ft/sec)
V_e = ending velocity in ft/sec = 0 ft/sec
a = deceleration in ft/sec^2, 0.48 g or -15.46 ft/sec^2 (0.48 g is 96% of 0.5 g)[1]
d = distance of the deceleration in feet, 133 ft

V_i = 64 ft/sec or 44 mph

Distance Needed for TAB Truck to Stop

Based on a calculated deceleration factor for the combination vehicle, a determined speed before braking, and a lag time for the brakes to actuate, the following data was used to calculate the distance needed for the driver to perceive and react to the warning lights and skid to a stop:

D = distance to skid to a stop from 44 mph = 133 ft

D_l= distance during brake lag time
= 0.5 sec x 64 ft/sec = 32 ft

D_r= distance during reaction time
= 1.5 sec x 64 ft/sec = 96 ft

Total distance needed to stop = 261 ft

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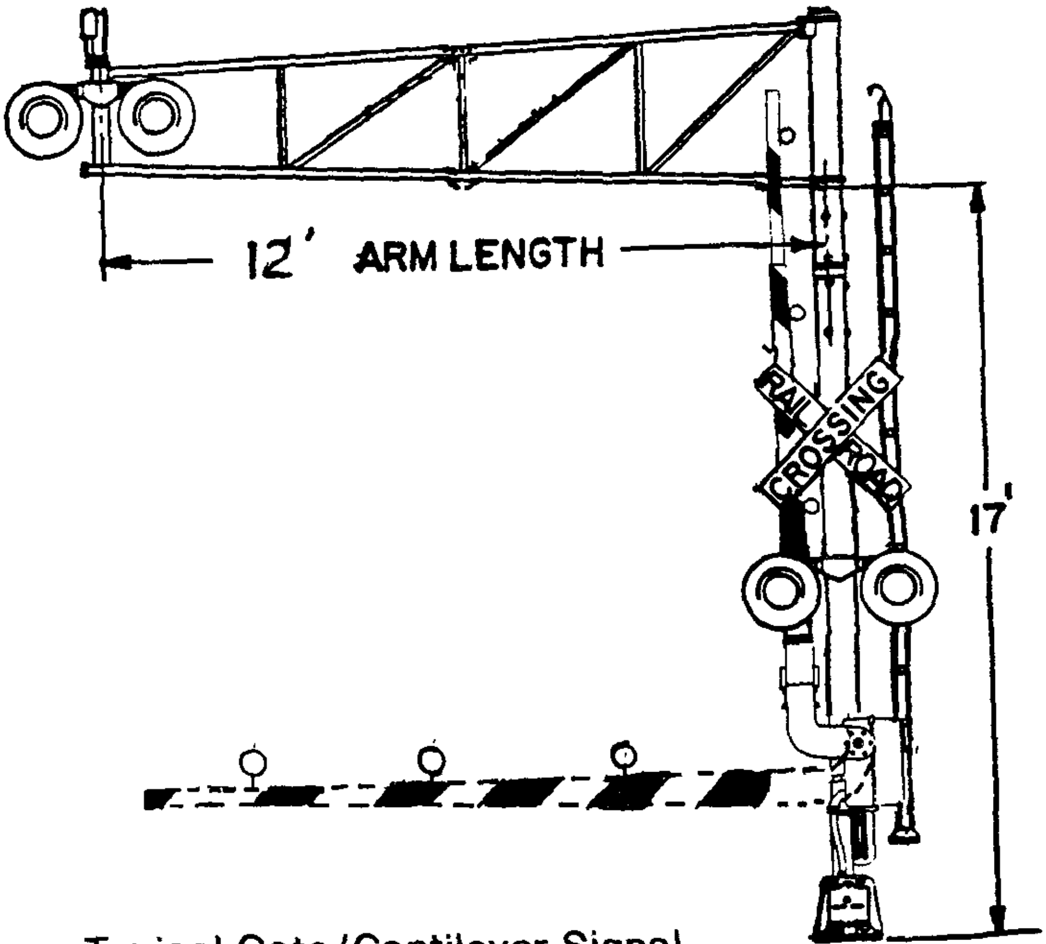
[1]A drag factor of .58 g was measured on the G-Analyst on dry pavement for the test TAB truck skidding to a stop at 25 mph. Adjusting for wet pavement reduction charts indicate to use .5 g for 100 percent braking efficiency. The accident truck had a 96 percent braking efficiency.

APPENDIX E

TYPICAL GATE/CANTILEVER SIGNAL



Typical Gate/Cantilever Signal

Source. SAFETRAN

*U.S.G.P.O:1990-281-626:20028