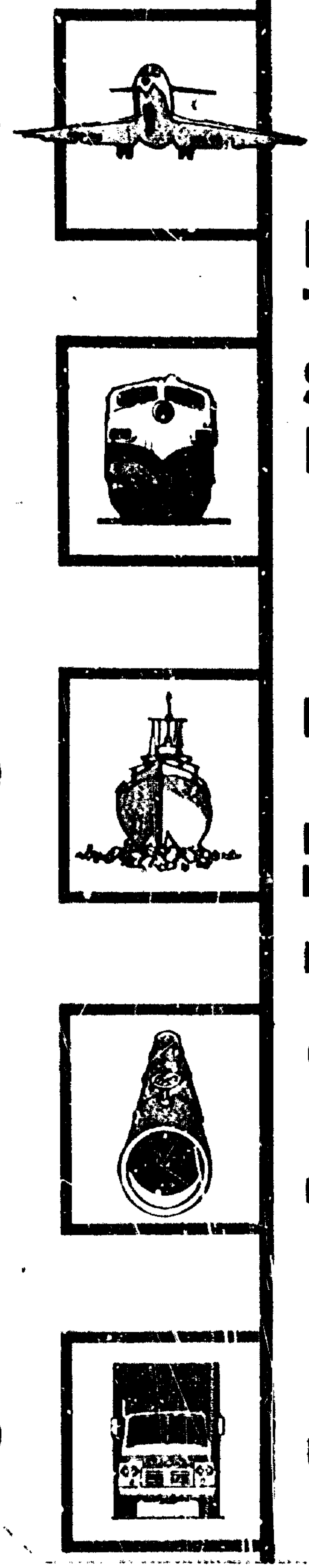

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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD

PULASKI, TENNESSEE

OCTOBER 1, 1975

REPORT NUMBER: NTSB-RAR-76-6

UNITED STATES GOVERNMENT

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16. Abstract

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The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

As a result of its investigation of this accident, the National Transportation Safety Board submitted three recommendations to the Federal Railroad Administration concerning six-wheel truck locomotives and emergency evacuation procedures.

PRICES SUBJECT TO CHANGE

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FOREWORD

This report is based upon an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: May 10, 1976

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD, PULASKI, TENNESSEE OCTOBER 1, 1975

SYNOPSIS

About 12:50 p.m. on October 1, 1975, 1 locomotive unit and 11 cars of Amtrak train No. 315 derailed on the Louisville and Nashville Railroad Company's track near Pulaski, Tennessee. Of the 69 persons on the train, 31 were injured. Property and equipment damage amounted to about $1,067,000.

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

FACTS

The Accident

At 11:22 a.m. on October 1, 1975, southbound Amtrak train No. 315, which consisted of 2 locomotive units and 12 cars, left Nashville, Tennessee, en route to Florida. The train, which is called "The Floridian," operates daily between Chicago, Illinois, and Jacksonville, Florida, where it is separated; part of it continues to Miami, Florida, and the other part goes to St. Petersburg, Florida.

The train is operated over Louisville and Nashville Railroad (L&N) tracks by L&N train and engine crews between Nashville and Birmingham. On October 1, 1975, the crew consisted of an engineer, a fireman, a conductor, and a flagman. The service personnel on the train were Amtrak employees.

Between mileposts BA 256 and BA 259, a slow order, 1/ which reduced the speed limit in that area to 60 mph, was in effect. Accordingly, as No. 315 approached milepost BA 256, the engineer reduced the train's speed to 60 mph. In order to maintain this speed, the engineer maintained a slight brake application and kept the throttle in position No. 6. As the train neared the south end of a 3° 8' curve at milepost BA 258.1, the engineer felt the locomotive lurch suddenly toward the east and then toward the west. When he felt the lurches, he looked into his rearview mirror and saw that the second unit of the locomotive was bouncing and swaying. He knew that it was derailed, so he immediately applied the brakes in emergency.

The fireman also felt the lurch and looked into his rearview mirror. He saw the second locomotive unit bounce and lean slightly westward. At the same time, he saw the dining car slide slowly down the embankment on the east side of the track and the cars behind the diner follow it. Neither he nor the engineer saw the cars ahead of the diner derail and go down the west side of the embankment.

When the train stopped, the engineer immediately radioed the train dispatcher and reported the derailment. Although the dispatcher acknowledged the transmission, the engineer did not hear the acknowledgement because the transmission was interrupted momentarily. Consequently, the engineer radioed other locations so that information of the accident could be relayed to the dispatcher and to emergency forces.

The conductor and the flagman, who were not in the locomotive units, first realized that something was wrong when the cars began to derail and to roll over the embankment. When the conductor realized that his train had derailed, he radioed the engineer of the derailment.

Except for one locomotive unit and one car, the entire train derailed. Of the 69 persons on the train, 31 were injured.

Postaccident Activities

Emergency units from several communities within a 50-mile radius responded to the accident. The U.S. Army base in Fort Campbell, Kentucky, sent Medevac helicopters to assist the injured. A few of the injured were evacuated by helicopter because the accident area was not accessible by highway. The Division of Civil Defense, Military Department of Tennessee, coordinated the emergency activities. The emergency rescue units, Amtrak, and L&N personnel evacuated the injured; all occupants had been evacuated

1/ A slow order gives a message of temporary conditions that require special operating caution, i.e., slow speed because of the track instability.

from the train within 25 to 30 minutes. The evacuation of passengers was hindered by the various positions in which the cars stopped. To reach the outside, passengers were forced to crawl over compartment partitions, through hallways with insecure foothold and handholds, and up vestibules with no prearranged handholds or footrests. (See Figure 1.) Doorway curtains hung over passageways and added to the confusion in the disarrayed interior.

Some end sliding doors had to be opened by an upward movement because the cars were lying on their sides. It was impossible to open these doors, either from the inside or the outside of the car, without mechanical assistance.

Most passengers were in the dining car at the time of the accident, and those most seriously injured during the accident were in the dining car. Passengers complained that they had been struck by loose dishes and furniture in the dining car during the derailment, and said that the furniture and the number of people in the dining car had hampered escape and rescue efforts. (See Figure 2.) The injuries to passengers consisted of broken bones, back injuries, neck injuries, cuts, and abrasions.

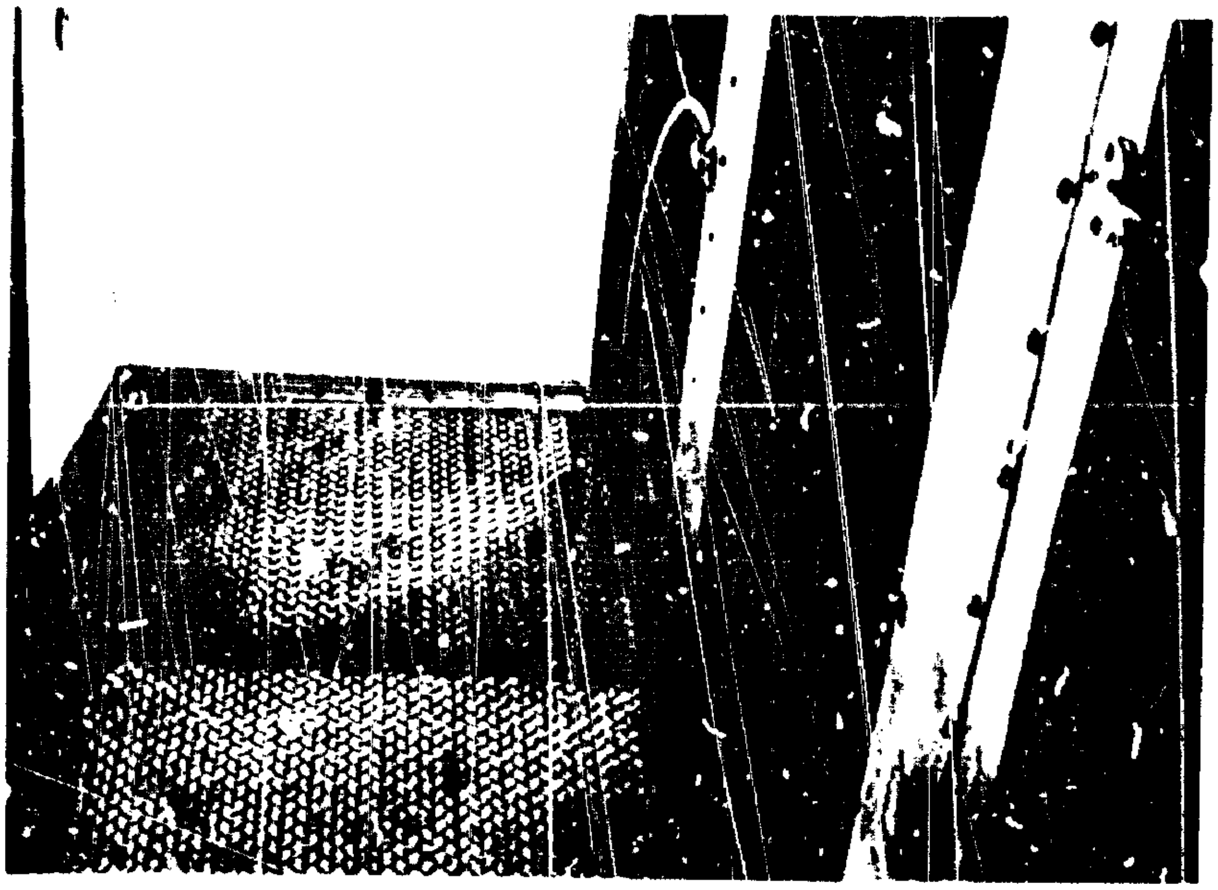


Figure 1. View of vestibule from bottom doors as car rests on its side, showing lack of handholds and footholds.

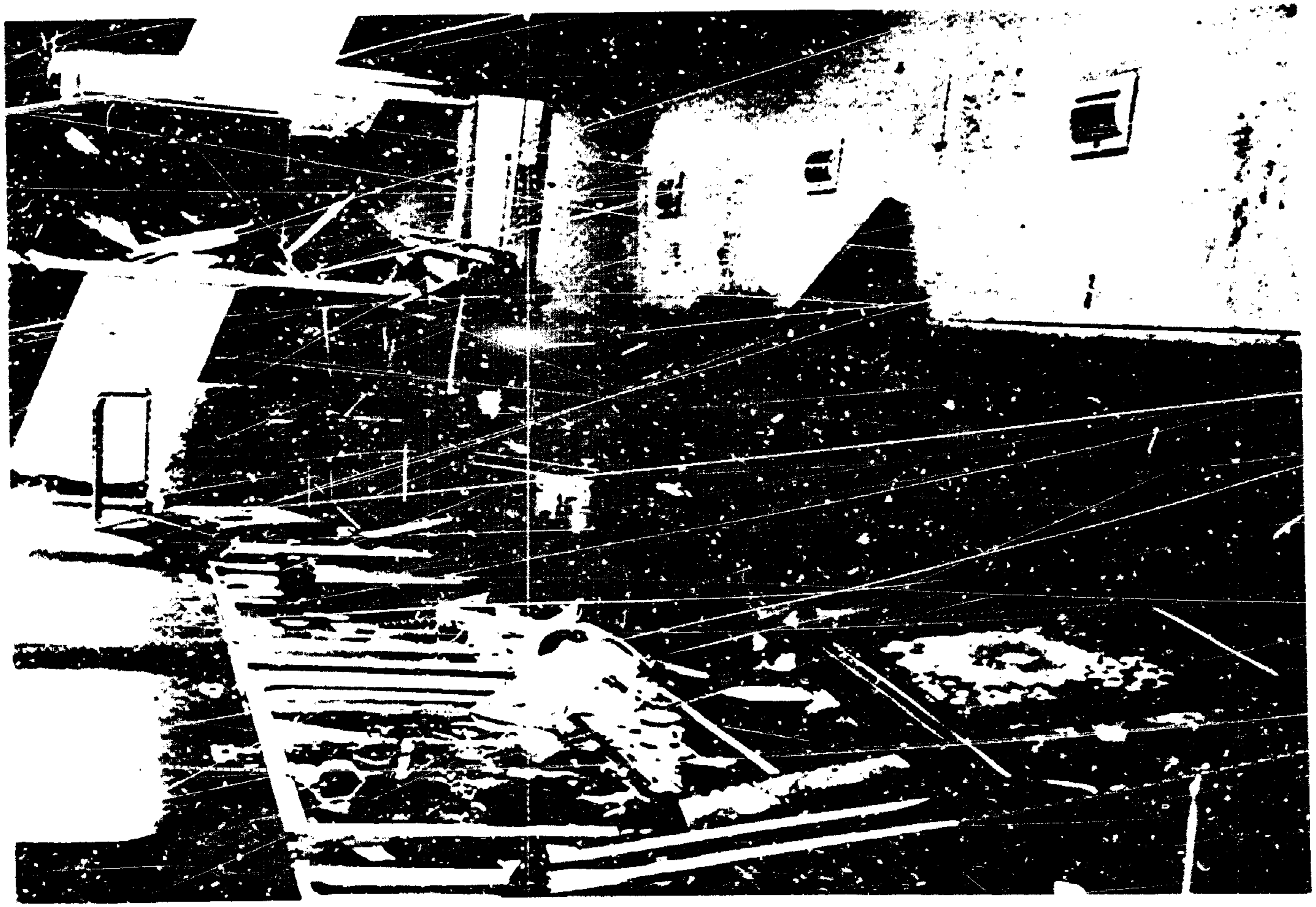


Figure 2. Loose and disarrayed furniture in the dining car.

The Accident Site

Train 315 derailed on a 3° 8' curve to the right at milepost BA 258.1, 258.1 miles from Louisville, Kentucky. (See Figure 3.) The speed limit through the curve is 60 mph for passenger trains. The grade in the vicinity of the accident site descends southward and varies from 0.2 to 0.5 percent. The track extends through a side-hill cut to a tangent fill at the south end of the curve. The fill continues for 540 feet, after which the track enters another cut and a 3° 7' curve to the right. The fill is from 35 to 40 feet high at its midpoint.

The track consists of 132-pound, RE, 39-foot-length rails, which are joined by 6-hole, 36-inch angle bars. ^ · outside rails of the curve are a mixture of curvemaster and flam ardened rails which were laid second position in 1973. There are about 12 rail anchors in each 39-foot length. The rails rest on 7 7/8- by 14-inch, 7-hole tie plates, which are supported by an average of 22 wood crossties in each 39-foot rail; the crossties rest on slag ballast. There are three to five spikes per tie per rail; this is in excess of the required number of spikes specified in the Federal Railroad Administration (FRA) Track Safety Standards. The curve on which the train derailed has a superelevation of about 4.1 inches (See Figure 4.) The variations in elevation and curvature generally are oscillatory in nature, going from more than median to less than median. These reversals occur in very short distances, and could cause the trucks of the locomotive to follow this pattern. Impulse lateral forces, as a result of this action, could be expected in addition to the lateral forces exerted in a normal curve negotiation. The gauge of the track through the curve varies from 4 feet 8 1/4 inches to 4 feet 8 7/8 inches. The standard gauge measurement is 4 feet 8 1/2 inches.

The Federal Track Safety Standards in effect are contained in 49 CFR 213. The FRA track inspector had noted no discrepancies in the track before the derailment, and he did not find any irregularities in the undisturbed track during his postaccident inspection.

The track is classified as Class 4, 2/ according to the Track Safety Standards. These standards set 57 mph as the maximum allowable operating speed for a 3° 15' curve with 4 1/2 inches of superelevation (49 CFR 213.57 (b)). The curve at milepost BA 258.1 has a curvature of 3° 8' and a speed limit of 60 mph. However, the Track Safety Standards allow a deviation of 1 1/4 inches on the superelevation of a curve (49 CFR 213.63) and a deviation in curvature of 1° 30' (49 CFR 213.55). 3/ This means that the elevation can be as little as 3 1/4 inches or as great as 5 3/4 inches and can have a maximum allowable operating speed of 60 mph.

2/ A Class 4 classification indicates that the track meets the Track Safety Standard requirements set forth in 49 CFR 213 for a maximum speed limit of 80 mph for passenger trains.

3/ 1.5 inches at midordinate of a 62-foot chord.

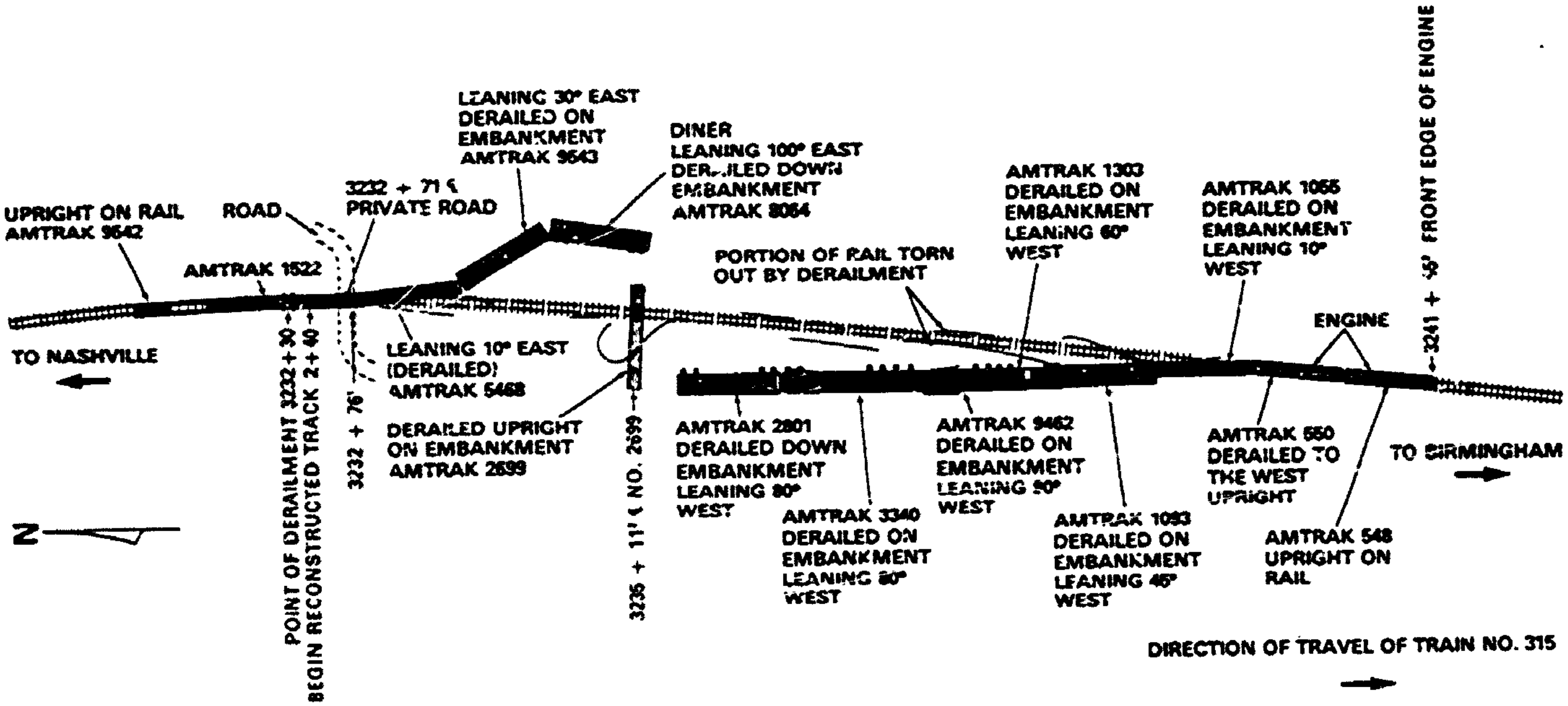


Figure 3. L & N Railroad Company M. P. B. A. 258.1 Frankewing, Tenn., derailment AMTRAK train No. 315, October 1, 1975, curvature 3° 8' R.

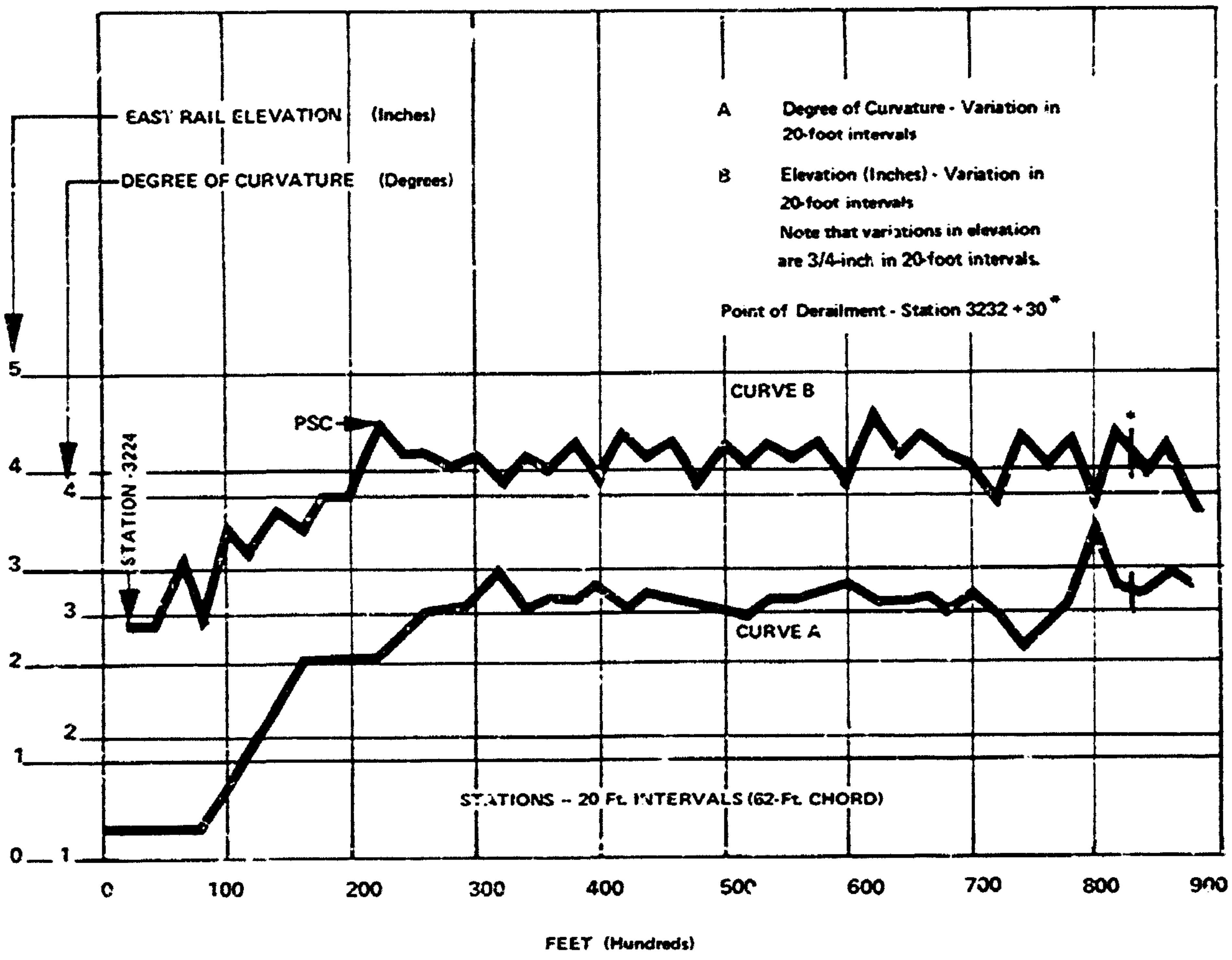


Figure 4. Approach to point of derailment from the north.

An assistant roadmaster inspects the track in the vicinity of milepost BA 258.1 twice weekly. The assistant division engineer had patrolled the track on September 29, 1975, and noted no discrepancies.

On September 17, 1975, the L&N tested the rails through the area of the accident with an ultrasonic rail-test car and determined that the track was in good condition.

On the day that the derailment occurred, an L&N work train, Work Extra 4082, had moved through the area of the derailment in both directions; it last passed milepost BA 258.1 at 11:19 a.m. as it moved south. Another train, Extra 4053 South, passed milepost BA 258.1 at 11:52 a.m. Neither the engineer of Work Extra 4082 nor the engineer of Extra 4053 South noted any irregularities in the appearance or the riding qualities of the track at that point. Unit 4053 was a type GP-38, four-wheel, truck locomotive.

Method of Operation

The accident occurred on the Birmingham Division of the L&N. Trains are operated over this portion of the Birmingham Division by train orders, timetable, general orders, bulletins, and automatic block signal indications. The signals are approach-lighted and are part of a traffic control system which is controlled from Birmingham, Alabama. The operating rules which govern L&N employees are contained in "Rules of the Operating Department," which was effective on July 1, 1966. Operating Rules 550 through 575 govern the movement of trains through the area where the accident occurred. There is no evidence that the crew of No. 315 violated any rules; speed recorder tapes on each locomotive unit indicated that the train's speed had been 60 mph immediately before the engineer made the emergency brake application. Also, there is no evidence that the crews of the track department were remiss in any of their responsibilities.

The Train

The train's consist was locomotive units 548 and 550, three baggage cars, two coaches, two sleeping cars, one dining car, and four coaches. The baggage cars were constructed of steel; the passenger cars were conventional, lightweight cars which were constructed of stainless steel and were equipped with tightlock couplers. The locomotive units were EMD (ElectroMotive Division, General Motors), SDP-40-F, passenger locomotives, which were built to Amtrak's specifications and were owned by Amtrak. (See Appendix A.) These locomotives are heavier than other type SD-40 locomotives. They were maintained by the Seaboard Coastline Railroad at Waycross, Georgia, and Hialeah, Florida.

Each locomotive unit was equipped with alertor, a deadman control, speedometers and speed-recording tapes, and an operable radio. The conductor was also provided with an operable portable radio, with which he could communicate with the engineer. The units did not have automatic train stop, speed-control, or cab signal equipment. They were subject to inspections and tests in accordance with the Federal Locomotive Inspection Act; they had not violated any of the requirements of the Act.

The locomotive units were equipped with an HT-C 3-axle truck like those used on other EMD products. These six-wheel truck locomotives have been involved in several accidents in which the rail apparently spread under them and turned over. This occurence seems to be more prevalent in a curve. Amtrak has tested the SDP-40-F locomotive on the tracks of the Penn Central Transportation Company (PC), and has determined that it develops high lateral accelerations which may produce excessive lateral forces.

The measured track lateral forces obtained during the tests for an E-8 locomotive (four-wheel truck) and an SDP-40-F locomotive are shown in Table 1.

TABLE 1

Speed	Track Lateral Force	
	SDP-40-F	E-8
65 mph	13,500 lbs	15,000 lbs
85 mph	24,000 lbs	21,500 lbs

When the engineer made the running brake test as the train was leaving Chicago, Illinois, the brakes made an undesired emergency application. The brakes were inspected but no defects which could have caused them to apply were found. The brakes made four other undesired emergency applications between Louisville, Kentucky, and the accident site. In three of these five instances, the brakes were not being used. Although the brakes were inspected repeatedly, no defects were found.

Damage to Property and Equipment

The L&N estimated the damage to the track and the cost of restoring the track and roadbed to be $27,300. The damage to the Amtrak equipment was estimated at $1.04 million.

Some windows in the dining car were shattered, but none were broken out as a result of the derailment. Some of the equipment had floors and undercarriages damaged by rails picked up during the derailment. Other damage was exterior denting and general crash marring.

Postaccident Inspection and Tests

After the derailment, investigators found marks on the rear wheels of the rear truck of locomotive unit 548 which indicated that the wheels had been derailed and that they had struck track angle bars, tie plates, and spikes. All wheels on unit 550 had been scarred by the derailment. The trucks of unit 550 were removed from the body assembly and its critical clearances and distances, as designated by the manufacturer, were measured. All measurements were within the design specifications or tolerances. No defects that could have caused the accident were found. (See Appendix B.)

Investigators determined that the locomotive stopped 915 feet beyond the first marks of the derailment. The first marks of the derailment were evident on the track structure at the south end of the curve, 60.1 feet north of the PCS (point of curve spiral). The spiral extends southward 288.7 feet to tangent track. A number of broken rails and battered joints, which resulted from the derailment, were found. One broken rail, which investigators suspected had caused the derailment, was found 83 feet south of the first marks of the derailment.

There were no batter marks on the receiving end of this rail. The break in this rail was analyzed by the Technical Center in the Research and Test Department of the Association of American Railroads. The tests indicated that bending stresses, caused by wheel flanges as they rolled in the web, had caused the rail to break.

The derailment demolished about 760 feet of track. The track's condition before the derailment occurred could not be determined except from the inspection records. However, the records, the inspection, and the measurements made of the track adjacent to the destroyed track, the curve geometry, and the tolerance of the track indicate that it was in compliance with the requirements specified by the FRA Track Safety Standards.

When the rail was examined after the accident, some of the line-holding spikes were raised and a few of them were loose enough to be pulled out by hand, but there was no evidence that the tie plates or the rail had moved laterally. The overall conditions of the wood ties was good, and the track was well-drained and well-maintained.

The brake system on each car was checked after the accident and Amtrak car No. 2699 was found to have a faulty brake valve. It failed to pass test No. 5 (test procedures, page 76, Manual No. 5039-21, Westinghouse Airbrake Company). During the bench test, reduction in air pressure initiated an emergency brake application on No. 2699.

ANALYSIS

The Derailment

As No. 315 moved southward through the curve at milepost BA 258.1, the second locomotive unit caused the outside rail to spread and to overturn. The wheels of the locomotive unit and the wheels of the following equipment must have traveled in the web of the rail, because the heavy marks in the webs of the east and west rails and the gouging and battering on the joint bars indicates that they were struck by the wheels of the train. The westward inclination of the second locomotive unit which was noticed by the fireman indicates that the east wheels were in the web of the rail and that the west wheels were off the rail.

When the west rail broke about 500 feet beyond the point of derailment, the third car and the cars behind it began to derail toward the west. As the third car and the cars behind it went over the embankment, they pulled the head cars off the track structure and roadbed. Probably the broken rail found 83 feet south of the derailment broke under the seventh car. This rail already was stressed badly by the locomotives and by the cars which had run over it with their wheels in the web. When it broke and separated, it allowed the eighth car to move toward the east and down the embankment. The diner pulled the cars behind it down the east side of the fill. At the beginning of this action, the entire train was still coupled. As a result of the gyrations of the cars, car No. 7 came uncoupled at both ends and came to rest perpendicular to the track. Except for car No. 7 the train did not uncouple. Undoubtedly, the fact that the train remained coupled prevented any violent gyrations and kept the cars from rolling over completely.

Overturning of the Track

The L&N restricts the speed of passenger trains to 60 mph through the curve at milepost BA 258.1. This is the maximum allowable operating speed for a 3^{o} 8' curve according to the formula prescribed in 49 CFR 213.57(b).

The maximum allowable operating speed as determined by this formula is based on a combination of such factors as speed, superelevation, and degree of curvature. Theoretically these factors set physical parameters that will not allow the generation of a lateral force which could cause the rail to overturn.

The curvature and the elevation of the track vary considerably along the curve in which the derailment occurred. However, these variations are within the tolerances allowed by the Federal Track Standards. The Manual for Railway Engineering (Fixed Properties), the American Railway Engineering Association, and the Engineering Division of the Association of American Railroads (Section 5-3-10) indicate that the elevation for equilibrium speed 4/ for a 3^{o} curve at 60 mph is 7.56 inches.

4/ Equilibrium speed is the speed at which the components of the centrifugal force and the weight in the plane of the track are balanced.

According to their criteria, a 3° curve should have an equilibrium elevation of 7.9 inches. Since the elevation for the curve at milepost BA 258.1 is only half of that required for equilibrium at 60 mph, a train will exert a lateral force on the curve's outside rail because it rides hard against that rail. The net effect of a decrease in elevation would be an increase in lateral force against the outside rail, because the elevation required for equilibrium would have decreased further.

At 60 mph, there is an unknown value of sustained lateral force against the outside rail of the curve, and variations in the track geometry generate additional lateral forces. These forces are induced as impulses because the wheels of the locomotive strike the uneven points in the alignment of the curve. This could cause an oscillatory harmonic effect, in which case these impulses would be cumulative, and add to those lateral forces already present. Engineering performance tests show that six-wheel trucks produce a higher lateral thrust than do four-wheel trucks. Also, six-wheel trucks are less tolerant of certain track defects than are four-wheel trucks.

Consequently, it appears that at least three factors were present which caused the rail to overturn:

a) The speed of No. 315 was equal to the maximum allowable speed for the curve but above the speed necessary to maintain equilibrium.

b) The cumulative impulse effects, which were produced by the variation in track geometry, tended to increase the lateral force.

c) The six-wheel trucks generated a higher lateral force than four-wheel trucks.

The rail's resistance to overturning is not known because the exact condition of the track before the derailment is not known.

There have been at least three other accidents 5/ that have occurred under similar circumstances -- i.e., a 3° -plus curve, a speed of 55 to 60 mph, and a locomotive with six-wheel trucks. These accidents suggest that the rail's resistance to overturning and the effect of variations in curve geometry on six-wheel trucks should be studied. Locomotive manufacturers, Amtrak, the railroads, and the FRA should cooperate in this effort. The FRA Track Safety Standards also should be reviewed to determine if they are adequate for the stresses imposed by six-wheel trucks.

5/ Amtrak Train No. 10 on Burlington Northern tracks at Flynn, Montana, January 5, 1976.

Amtrak Train No. 15 on Atchison, Topeka and Santa Fe tracks at Ardmore, Oklahoma, January 14, 1974.

Amtrak Train No. 81 on Seaboard Coastline tracks at Wake Forest, North Carolina, August 12, 1974.

Track-Train Dynamics

Both the railroad industry and The Federal Railroad Administration have studied track-train dynamics. The manufacturers of the six-wheel truck present a substantial amount of test data which indicates, in theory, that the performance of the six-wheel trucks is superior to that of four-wheel trucks in some instances and that the reactive forces generated by the two are nearly the same for all cases except for that of a lateral force. They admit that a six-wheel truck generates more lateral force than does a four-wheel truck, but they claim that the force is still below that which is required to overturn a rail or to cause a wheel to climb up on the rail. Since the forces required to overturn a rail or to cause a car wheel to climb out of the gauge have been determined to be a relationship between lateral forces (L) and vertical forces (V), the manufacturers have established L/V ratios as criteria for forces required for rail overturn or for wheel climb. In order for a rail to overturn, the L/V ratio has to exceed 0.5 or 0.6 and in order for a wheel to climb the rail, the L/V ratio has to exceed 0.9. Tests show that the L/V ratio for an SDP-40-F locomotive is well below these values. Therefore, the concensus among the manufacturers is that the amount of lateral force generated is not the only factor which causes a rail to overturn. The manufacturers believe that the duration of lateral load is also a factor. An L/V ratio of 0.5 or 0.6 generally will not cause a rail to overturn unless the high ratio is maintained for a period of time. Curvature of the rails may also be a factor; the problem of rails being overturned by six-wheel trucks seems to be more evident in curves with a curvature greater than 2°.

Since there are unknown factors involved, possibly the tolerance in track geometry as outlined by the Track Safety Standards allows too much variance to accommodate the six-wheel truck locomotives.

Rescue and Escape Procedures

Passenger equipment of the type used on No. 315 does not permit rapid access for rescue operations or rapid escape for passengers.

When a passenger car is on its side, usually the only way out of the car is to climb up. Without planned footrests or handholds to assist passengers to climb up from within the vestibule, escape from the car is hindered and becomes hazardous. Handrails, which aid passengers who are detraining from an upright car, and car construction ledges are the only available footing on the end vestibule opening.

Loose furniture and tableware also hindered escape efforts. Much of this equipment had to be moved before an escape passageway could be established. In order to escape from the diner, passengers had to crawl over open doorways which had no stabilizing guidebars or handrails. Rescue personnel worked from the outside of the car to help passengers overcome some of these impediments, but they were hampered in their efforts because their access to the inside of the car was limited.

Possible Emergency Brake Application

It could not be determined whether an undesired emergency brake application occurred just before the derailment. However, even if an emergency brake application had been initiated by the defective brake valve on the seventh car, it would not have increased the tendency of the locomotive to overturn the rail. Since the train was being operated under power with a slight brake application, the train should have been stretched. If emergency braking had been initiated at the seventh car, the tension would have been maintained in the train. This would have tended to decrease the lateral force which locomotive wheels were exerting on the outside rail.

CONCLUSIONS

1. The crew operated train No. 315 in accordance with applicable rules.

2. The track condition and the maintenance schedule conformed with the FRA Track Safety Standards for Class 4 track.

3. Car No. 2659 was being operated with a faulty brake valve which apparently caused several unwanted emergency brake applications.

4. An undesired emergency brake application at milepost BA 258.1 would not have increased the tendency of the locomotive to overturn the rail.

5. The variations in elevation and track curvature could have set up the condition necessary for the locomotive to develop excessive lateral forces, which exceeded the rail's resistance and caused it to turn over.

6. The broken rails found after the derailment at the scene of the accident were broken during the derailment.

7. The rails were broken because of bending stresses caused by the wheel flanges as they rolled in the web.

8. The outside rail was turned over by the lead truck of the second locomotive unit by a combination of high lateral forces generated by the six-wheel truck locomotive, and the inability of the track structure to accommodate those forces even though the track met the applicable FRA standards for Class 4 track.

9. There is a need to continue to study the phenomena associated with rail climb and rail overturn in connection with the six-wheel truck to determine the cause and the method to correct it.

10. Sliding end doors on passenger cars cannot be opened without mechanical aids when the required movement is upward.

11. When a car comes to rest at a severe angle, escape routes from the car's interior are obstructed by open compartment doors and hanging curtains, and escape is restricted by the lack of escape hatches in the ceiling of the car.

12. Loose furniture is a hazard during an accident because it may hit persons or block escape routes.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

RECOMMENDATIONS

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

"Review the Federal Track Safety Standards to determine if their current requirements are adequate for the safe accommodation of the six-wheel truck locomotives. (R-76-20)

"Require that rail passenger equipment be fitted with roof hatches so that passengers can escape through the ceiling of a car which is lying on its side. (R-76-21)

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

BY THE NATIONAL TRANSPORTATION SAFETY BOARD.

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

May 10, 1976

APPENDIX A

Excerpts from GM Technical Manual for SDP-40-F Locomotive

MODEL SDP40F 3000 HP Six Motor Diesel-Electric Locomotive.

TYPE AAR designation (C-C), Common Designation (0660).

*****

NOMINAL DIMENSIONS

Distance, pulling face of coupler to centerline of truck	Front 12'8"
	Rear 13'8"
Distance between bolster centers	46'0"
Truck -- rigid wheel base	13'7"
Distance, pulling face front coupler to rear coupler	72'4"

*****

DRIVE

Driving motors	Six
Driving wheels	6 Pair
Diameter wheels	40"
Gear Ratio	57:20

WEIGHTS AND SUPPLIES

Total loaded weight on rails (including calculated weight of dual steam generators and 6000 gallon total fuel and water capacity)	396,000# ± 4,000

*****

CURVE NEGOTIATION

Truck swing limits single unit curve negotiation to a 30° or 193 ft. radius curve.

Two units coupled in multiple limited by coupler swing to a 21° or 274 ft. radius curve (equipped with "E" coupler).

Locomotive coupled to an 87 ft. passenger car limited by car coupler swing to a 19°30' or 295 ft. radius curve (equipped with "E" coupler).

Two units coupled in multiple limited by coupler swing to a 19°30' or 295 ft. radius curve (equipped with "F" coupler).

Locomotive coupled to an 87 ft. passenger car limited by car coupler swing to a 17°30' or 330 ft. radius curve (equipped with "F" coupler).

APPENDIX A

TRUCK ASSEMBLIES — Two flexible, three motor, six wheel high traction, HTC truck assemblies are provided per locomotive. The high traction performance of the HTC truck is accomplished by three design characteristics: a large diameter center bearing, a stiff bolster suspension coupled with a relatively soft journal suspension, and traction motors oriented in one direction in each truck.

The new high traction truck is not interchangeable with previous three-axle trucks; however, there is a high degree of interchangeability maintained between truck components. Moreover, the simplicity of the HTC truck design enhances accessibility and maintainability.

PRIMARY SUSPENSION — A relatively soft primary suspension is provided by a combination of journal springs and hydraulic shock absorbers. The double coil journal spring assemblies minimize wheel load variations caused by rail profile irregularities. Hydraulic shock absorbers between the truck frame and middle axle journal boxes provide the vertical damping necessary for good riding quality.

SECONDARY SUSPENSION — Four stiff rubber pads, located between the truck frame and H shaped bolster, constitute the secondary suspension. These sandwich type pads are the primary factor in limiting weight transfer and are the principal source of lateral damping for the truck. In addition, the rubber pads both isolate the road noise which was previously transmitted between the bolster and the truck through steel springs, and provide additional vertical snubbing for the suspension.

AXLES — Axles with 6-7/8" journals to suit Hyatt roller bearings. Axle material conforms to physical properties of current AAR specifications. Axles are splined at one end only.

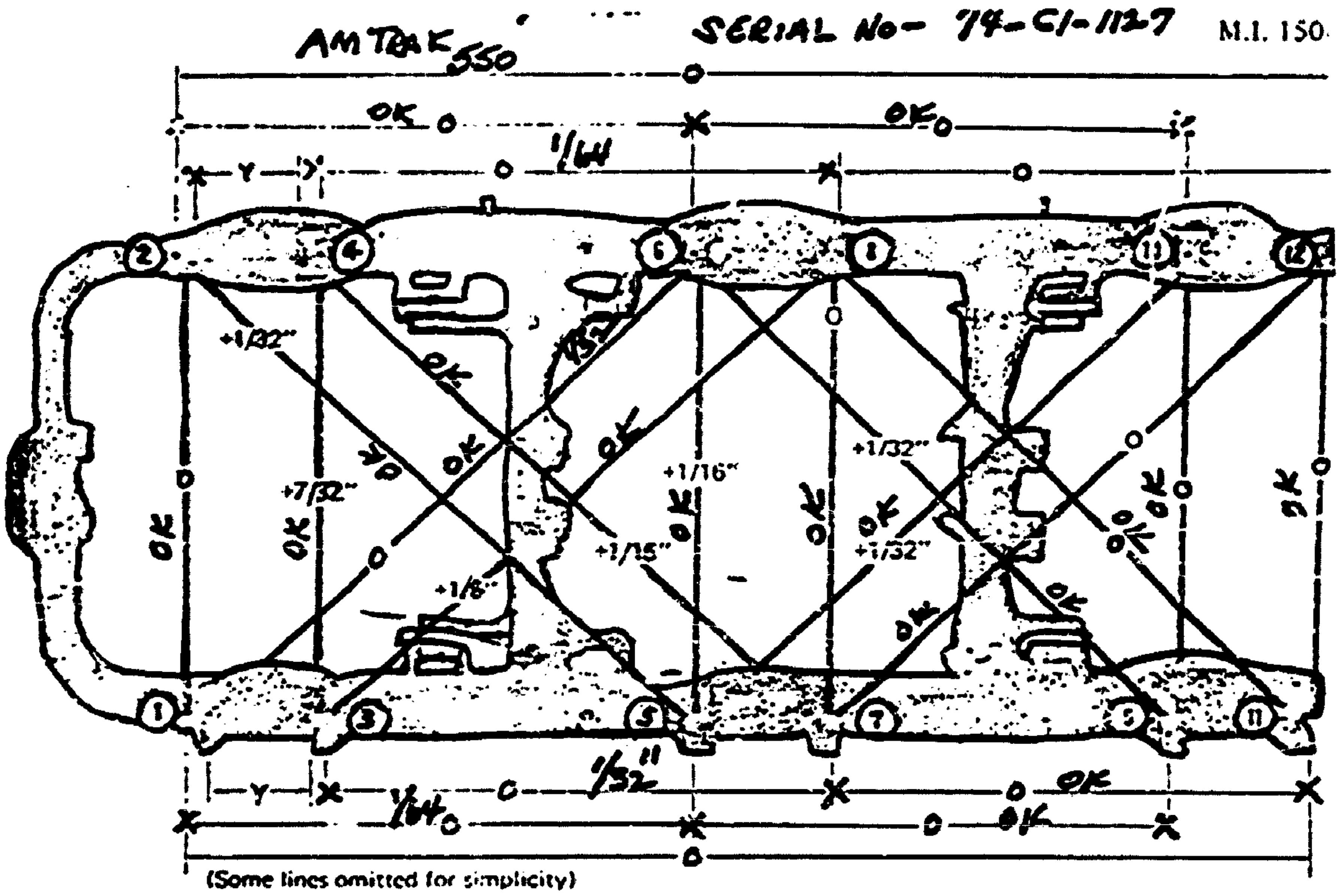
WHEELS — Class BR wrought steel heat treated, rim quenched, 40" diameter with 2-1/2" rim. Wheel treads with cylindrical contour are finished smooth and concentric. AAR diameter index groove is provided to measure true wheel diameter for wheel size matching. All wheels are hub stamped in accordance with AAR alternate marking.

APPENDIX A

JOURNAL BOXES	Locomotive equipped with Hyatt JEM roller bearings of EMD design. Improved rear cover seal and oil fill cup for improved oil retention and inspection provided. Crowned rollers extend bearing life. Latoral thrust is taken through a cushioning arrangement directly by the box with improved oil flow characteristics over thrust block. Journal box pedestal guides provided with spring steel wear plates.
PEDESTALS	Equipped with composition nylon liners bolted to frame.
PEDESTAL TIE BARS	Fitted and applied at the lower end of the pedestal legs, held in position by bolts.
TRUCK CENTER BEARING RECEPTACLE	Truck center bearing receptacle provided with wear plates and rubber dust guard.
SIDE BEARINGS	Friction type side bearings.
INTERLOCKS	Body and truck interlocks serve as safety devices in case of derailment. Antisliding stops are provided between truck bolster and underframe bottom place.
TRUCK BRAKES	Single shoe type brake rigging provided on each wheel, operated by four truck frame mounted brake cylinders. Composition shoes are standard.
SLACK ADJUSTERS	EMD design pin type slack adjusters.
BRAKE PINS	All pins and bushings hardened and ground.
HAND BRAKE	Hand brake provided for the locomotive operates on two axles of one truck. Both trucks provided with a lever for hand brake connection, making trucks interchangeable. Application of a 125 pound force to the rim of the 20" hand brake wheel will provide sufficient braking power to hold the fully loaded locomotive on a 3% grade. Hand brake modified with shortened shaft to allow maximum aisle clearance.
GEAR RATIO	57:20 gear ratio provides full horsepower to 94 MPH and a minimum continuous speed of 16.1 MPH.

APPENDIX A

INSPECTION COVERS	Traction motors provided with quick access hinged type bottom inspection covers.
HUCK FASTENERS	Huck bolts are provided on traction motor gear cases.



Truck measurements of locomotive 550.

APPENDIX B

Locomotive 550 -- measurements (inches)

	Front	Rear
Coupler swing -	L.S. - 3 3/4" R.S. - 1",	L.S. - 2" R.S. 3 1/2"
Coupler height-	34"	33"

Bolster Wear Plates

Front	R.S. 1/8" -- L.S. 1/16"
Rear	R.S. 1/8" -- L.S. 1/8"

Box Liner Lataral

R1 - 3/16", R2 - ¼", R3 - 3/16", R4 - 3/16", R5 - ¼", R6 - 3/16",
L1 - 5/16", L2 - 5/16", L3 - 3/16", L4 - ¼", L5 - ¼", L6 - 3/16"

Pedestal Liner to J-box

R1 - 5/32", R2 - ¼", R3 - 5/32", R4 - ¼", R5 - 5/16", R6 - 3/16"
L1 - 3/32", L2 - 3/16", L3 - 3/16", L4 - 3/16", L5 - 1/8", L6 - 1/8"

Side Bearing Clearance

R1 - ¼", R2 - 1/8", R3 - 23/32", R4 - ¼",
L1 - ¼", L2 - ¼", L3 - ¼", L4 - 5/16"

Wheel Tram

1- 53 5/16" 2- 53 5/16" 3- 53 5/16"
4- 53 5/16" 5- 53 5/16" 6- 53 5/16"

UNIT 550
DATE 10-7-75

	FLANGE THICKNESS			HEIGHT OF FLANGE				RIM THICKNESS			
R1	5	L1	5	R1	1 1/8	L1	1 1/8	R1	1 5/8	L1	1 11/16
R2	2	L2	2	R2	1 1/8	L2	1 1/8	R2	1 7/8	L2	2
R3	0	L3	1	R3	1 3/16	L3	1 1/8	R3	2 1/4	L3	2 1/4
R4	2	L4	2	R4	1 1/16	L4	1 1/16	R4	2	L4	2
R5	-2	L5	2	R5	1 1/8	L5	1 1/8	R5	1 7/8	L5	1 7/8
R6	0	L6	1	R6	1 1/8	L6	1 1/8	R6	2 3/16	L6	2 1/4

FORM NO. 1441.E.2-12.65
L & N R R CO
OFFICE GENERAL SUPT. MOTIVE POWER

Inspector /s/ J. D. Bunch

Foreman

Wheel measurements (inches)

BRAKE REPORT

DATE MADE 10-3-75

LOCOMOTIVE UNIT # AMT 550

PISTON TRAVEL (inches)				WHEEL REPORT SPOTS OR FLATS			
R 1	3-3/16	L 1	3	R 1	None	L 1	
R 2	2-13/16	L 2	2-7/8	R 2	"	L 2	
R 3	2-3/4	L 3	2-[illegible]/4	R 3	"	L 3	
R 4	1-1/2	L 4	1-1/2	R 4	"	L 4	
R 5		L 5		R 5		L 5	
R 6		L 6		R 6		L 6	

ENGINE BRAKE APPLY LBS 72 SECONDS 4 RELEASE SECONDS 4 HOLDS

AUTOMATIC BRAKE APPLY LBS 78 SECONDS 9 RELEASE SECONDS 9 HOLDS

EMERGENCY BRAKE APPLY LBS 93 SECONDS 13 RELEASE SECONDS 19 HOLDS

BRAKE PIPE LEAKAGE LBS 0 PER MINUTE

MAIN RESERVOIR LEAKAGE LBS 0 PER MINUTE

ORIFICE AIR COMPRESSOR GOOD

MAIN RES. CHECK VALVE GOOD

CONDITION BRAKE SHOES GOOD FITTED TO WHEELS GOOD

CONDITION BRAKE RIGGING GOOD

MANUAL OPERATING
Sand only of LF and RB
ALL SANDERS OPEN AND LINED TO RAIL

TEST DATES MONTHLY 9-23-75

3 Mos.-- 8-2-75 Air on all sanders

EMERGENCY SANDING OPERATING

6 Mos.-- " SAFETY CONTROL DEAD MAN PEDAL DUMPS SECONDS
BRAKE CYL PRESSURE- LBS SECONDS

12 Mos.-- " Cut Out

24 Mos.-- "

48 Mos.-- 4-17-74

REMARKS--

Inspector (Sign) /s/ Kenneth O. Dotson

Officer in Charge (Sign) Same

Loco - AMTRAK 550

Vertical and Horizontal snubbers on No. 1 truck tested and are fit for service

/s/ J.S. Bush

10-8-75

AMTRAK Locomotive No. 550

#2 TRUCK

Vertical snubber right side defective.

Left snubber and both horizontal snubbers satisfactory for service.

/s/ W.E. Stoecker

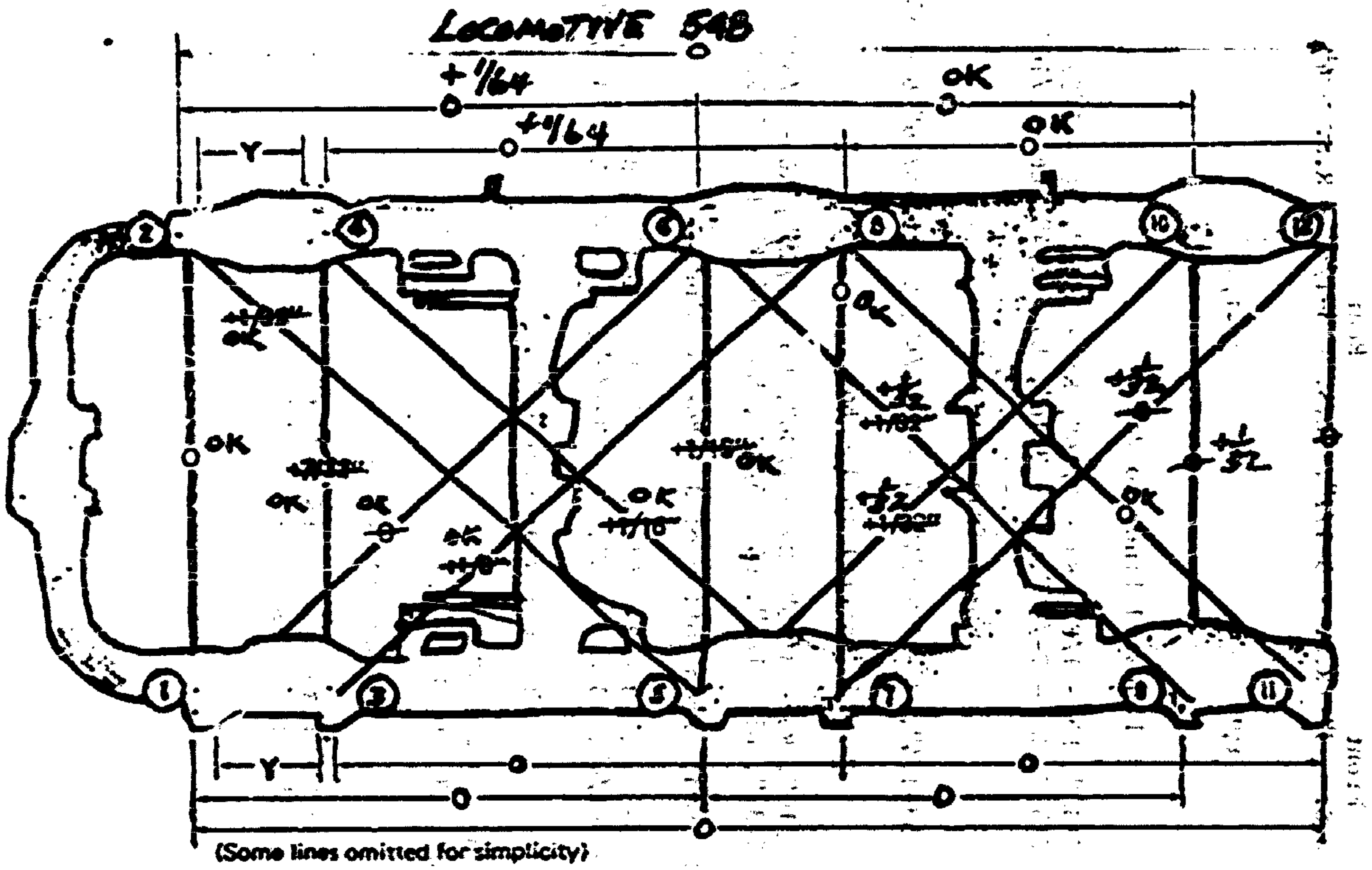
10-9-75

APPENDIX B

Lateral Clearances in Truck (inches)

WHEEL	#1 Truck #1	#1 Truck #2	#1 Truck #3	#2 Truck #4	#2 Truck #5	#2 Truck #6
Left A	1-7/16	1-5/8 (1-10/16)	1-7/16	1-9/16	1-10/16	1-7/16
Left B	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16
Left C	3/16	1/8 (2/16)	0	2/16	1/16	0
Right A	1-1/2 (1-8/16)	1-7/16	1-3/4 (1-12/16)	1-7/16	1-8/16	1-12/16
Right B	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16
Right C	0	0	3/16	1/16	1/16	2/16
LA + RA + LC + RC	2-18/16	2-19/16	2-22/16	2-19/16	2-20/16	2-21/16
LB + RB	2-14/16	2-14/16	2-14/16	2-14/15	2-14/16	2-14/16
LA + RA + LC + RC - LB - RB	1/4 2-(4/16)	5/16	1/2	5/16	6/16	7/16

Lateral clearances measured in accordance with EMD's No. 1552.



Truck measurements of locomotive 548.

APPENDIX B

Locomotive 548 - measurements (inches)

LOCO. 548

	Front		Rear	
Coupler Swing -	L.S. - 3"	R.S. - 3-1/2",	L.S. - 3-1/4"	- R.S. - 4"
Coupler Height -	34"		33-1/2	

Pedestal Liner to Box

R1 - 3/16", R2 - 7/32", R3 - 1/8", R4 - 3/16", R5 - 3/16", R6 - 5/32"
L1 - 3/16", L2 - 7/32", L3 - 7-/32", L4 - 3/16", L5 - 1/4", L6 - 3/16"

Wheel Tram

1 - 53-5/16", 2 - 53-1/4", 3 - 53-1/4", 4 - 53-1/4", 5 - 53-5/16" 6 - 53-5/16"

Side Lateral in J - Box

R1 - 7/32", R2 - 3/16", R3 - 3/16", R4 - 7/36", R5 - 3/16", R6 - 5/32"
L1 - 3/16", L2 - 5/32", L3 - 1/4", L4 - 5/32", L5 - 5/32", L6 5/32"

Distance from Bottom of J - Box to Binder

R1 - 3-1/4", R2 - 3-3/4", R3 - 3-3/4", R4 - 4", R5 - 3-3/4", R6 - 3-7/8"
L1 - 3-1/4", L2 - 4-1/4", L3 - 3-7/8", L4 - 3-7/8", L5 - 4", L6 - 3-7/8"

Bolster Wear Plates

R1 - 1/16", R2 - 0" R3 - 1/8", R4 - 0
L1 - 0, L2 - 1/16", L3 - 0, L4 - 1/16"

Side Bearing Clearance

R1 - 5/16", R2 - 7/32", R3 - 5/16", R4 - 7/16"
L1 - 7/16", L2 - 7/16", L3 - 3/8", L4 - 3/8"

UNIT 546
DATE 10-7-75

	FLANGE THICKNESS			HEIGHT OF FLANGE				RIM THICKNESS			
R1	2	L1	3	R1	1 1/8	L1	1 1/8	R1	1 3/8	L1	1 3/8
R2	0	L2	4	R2	1 1/4	L2	1 5/16	R2	2 3/16	L2	2 1/8
R3	0	L3	0	R3	1 5/16	L3	1 5/16	R3	2 3/16	L3	2 1/8
R4	1	L4	1	R4	1 1/16	L4	1 1/16	R4	2 1/2	L4	2 1/2
R5	4	L5	0	R5	1 5/16	L5	1 1/4	R5	2 1/8	L5	2 1/8
R6	0	L6	0	R6	1 5/16	L6	1 5/16	R6	2 1/8	L6	2 1/16

FORM NO. 1441.E.2-12.65
L & N R R CO
OFFICE GENERAL SUPT. [illegible]IVE POWER

Inspector /s/ Watts

Foreman

Wheel measurements (inches)

APPENDIX B

BRAKE REPORT

APPENDIX B

DATE MADE 10-3-75

LOCOMOTIVE UNIT # AMT. 548

PISTON TRAVEL				WHEEL REPORT SPOTS OR FLATS			
R 1	1-5/8	L 1	2-1/4	R 1	None	L 1	
R 2	3-1/4	L 2	2-1/2	R 2	"	L 2	
R 3	2-7/8	L 3	3-1/2	R 3	"	L 3	
R 4	2-3/8	L 4	2-3/8	R 4	"	L 4	
R 5		L 5		R 5		L 5	
R 6		L 6		R 6		L 6	

ENGINE BRAKE APPLY LBS 72 SECONDS 3 RELEASE SECONDS 5 HOLDS

AUTOMATIC BRAKE APPLY LBS 78 SECONDS 7 RELEASE SECONDS 11 HOLDS

EMERGENCY BRAKE APPLY LBS 93 SECONDS 12 RELEASE SECONDS 18 HOLDS

BRAKE PIPE LEAKAGE LBS 0 PER MINUTE

MAIN RESERVOIR LEAKAGE LBS 1 PER MINUTE

ORIFICE AIR COMPRESSOR GOOD

MAIN RES. CHECK VALVE GOOD

CONDITION BRAKE SHOES GOOD FITTED TO WHEELS GOOD

CONDITION BRAKE RIGGING GOOD

TEST DATES MONTHLY 9-12-75

3 Mos.-- 7-17-75

6 Mos.-- "

12 Mos.--"

24 Mos.--"

48 Mos.--4-17-74

MANUAL OPERATING
Sand pipe bad because of derailment
ALL SANDERS OPEN AND LINED TO RAIL

Air on all sanders

EMERGENCY SANDING OPERATING
SAFETY CONTROL DEAD MAN PEDAL DUMPS SECONDS
BRAKE CYL PRESSURE- LBS SECONDS
Cut Out

REMARKS--

Inspector (Sign) /s/ Kenneth O. Dotson

Officer in Charge (Sign) Same

7016