PB83-916307

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

ILLINOIS CENTRAL GULF RAILROAD COMPANY
FREIGHT TRAIN DERAILMENT
FORT KNOX, KENTUCKY
MARCH 22, 1983

NTSB/RAR-83/07

UNITED STATES GOVERNMENT

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16. Abstract

About 4:42 a.m. on March 22, 1983, 13 cars (3 tank cars and 10 boxcars) of Illinois Central Gulf Railroad Company train SML-4-21, 1st No. 64, engine 702, derailed in a 2° left curve at Fort Knox, Kentucky, while moving about 28 mph over an excessively worn, badly shelled rail which tipped and broke. During the derailment, two tank cars containing chloroprene overturned, and chloroprene began leaking from a dome valve of one of the cars. At 9:00 a.m., three E. I. DuPont hazardous material experts from Louisville, Kentucky, arrived at the derailment site. About 9:45 a.m., the leak was stopped. Evacuation of the area was not necessary. There were no injuries as a result of the accident. Damage was estimated at $199,831.

The National Transportation Safety Board determines that the probable cause of this accident was the tipping and breaking of an excessively worn, badly shelled curve rail at a point weakened by a detail fracture when it was subjected to normal outward lateral forces. Contributing to the tipping and breaking of the rail were the poorly maintained irregular cross level track and the absence of superelevation of the track on the 2° curve. Also contributing to the accident was the failure of the Illinois Central Gulf Railroad management to monitor adequately its track maintenance program and to effectively enforce inspection and maintenance procedures.

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RAILROAD ACCIDENT REPORT

Adopted: August 9, 1983

ILLINOIS CENTRAL GULF RAILROAD COMPANY FREIGHT TRAIN DERAILMENT FORT KNOX, KENTUCKY MARCH 22, 1983

SYNOPSIS

About 4:42 a.m. on March 22, 1983, 13 cars (3 tank cars and 10 boxcars) of Illinois Central Gulf Railroad Company train SML-4-21, 1st No. 64, engine 702, derailed in a 2° left curve at Fort Knox, Kentucky, while moving about 28 mph over an excessively worn, badly shelled rail which tipped and broke. During the derailment, two tank cars containing chloroprene overturned, and chloroprene began leaking from a dome valve of one of the cars. At 9:00 a.m., three E. I. DuPont hazardous material experts from Louisville, Kentucky, arrived at the derailment site. About 9:45 a.m., the leak was stopped. Evacuation of the area was not necessary. There were no injuries as a result of the accident. Damage was estimated at $199,831.

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INVESTIGATION

The Accident

On March 21, 1983, Illinois Central Gulf Railroad Company (ICG) train SML 4-21, 1st No. 64, engine 702, departed Memphis, Tennessee, en route to Louisville, Kentucky. The train consisted of four locomotive units and 47 loaded and 41 empty cars comprising 6,446 tons. At 10:45 p.m., e.s.t., 1/ the train stopped at Central City, Kentucky, a crew change point, and a five-man operating crew assumed operational control of the train.

About 11:10 p.m., as train 1st No. 64 departed Central City (milepost 125.5 measured from Louisville), the engineer made a running brake test; he did not note any operational problems. Between mileposts 119 and 118 and again between mileposts 109 and 105, the engineer checked the locomotive speed indicator by a time and distance measurement and found it to be accurate at 30 mph.

1/ All times herein are eastern standard time.

At Cecilia, Kentucky, milepost 47, train 1st No. 64 stopped. Seventeen empty cars and one loaded car (572 tons) were set off and 2 loaded cars and 6 empty cars (402 tons) were picked up. The engineer made a set and release brake test and again noted no operational problems with the train's brakes. Then the train left Cecilia, with 48 loaded and 30 empty cars, for a train tonnage of 6,276 tons.

North of Cecilia, at milepost 33, train 1st No. 64 approached a slight downgrade. At the beginning of the downgrade, the engineer applied the brakes by making a service brakepipe reduction of about 7.5 psi of air while the throttle was in the No. 4 run position. He said that the train was a good handling train and that less than the maximum authorized speed of 30 mph was maintained with no difficulty. As train 1st No. 64 passed milepost 32, the speed indicator was registering about 25 mph. The engineer released the train brakes and reduced the throttle gradually until it was about (as he remembered) the No. 2 run position. As the train came into the Fort Knox area, the speed indicator was registering about 28 mph. The engineer said that after the locomotive and head cars had passed through a 2° left curve, he was about to make a minimum brakepipe reduction to maintain the speed of the train to less than 30 mph when he felt a surge in the train and the train's brakes applied in emergency. The locomotive stopped with no difficulty about 1,300 feet north of the point of the brake application.

Thirteen cars, including 3 tank cars followed by 10 boxcars, derailed beginning with the 33d car from the locomotive through the 45th car. (See figure 1). The first and second derailed tanks cars (the 33d and 34th cars), which contained liquid chloroprene, overturned. The two cars uncoupled from the front part of the train because the coupler on the 32nd car broke, but they remained coupled together and nearly parallel to the track. Debris entered the mechanism of the vacuum relief valve on the first derailed car, precluding the valve from reseating properly and allowing liquid chloroprene to discharge into the atmosphere at a rate of about 5 gallons per minute. The liquid chloroprene gasified at atmopsheric pressure, but it did not ignite and evacuation of the area was not required.

The third derailed car (the 35th car), which was an empty tank car, also overturned but remained coupled to the 33d and 34th cars, but it separated from the 36th car. It stopped nearly parallel to the track. During an earlier trip, the tank car had been loaded with hydrochloric acid. Hydrochloric acid is a corrosive material which burns only with difficulty, and it is not explosively violent. It will emit irritating fumes, but since the tank car showed no puncture damage to the tank shell, and any residual amount would have been small, it posed no threat to nearby residents, crewmembers, or the environment. The 36th car overturned and came to rest nearly perpendicular to the track. The 37th through the 44th cars also jackknifed and stopped perpendicular to the track, leaning at various angles. (See figure 2.) Only the north end of the 45th car derailed and it remained upright and coupled to the 46th car. The boxcars contained inert lading, such as lumber, wood products, and vinyl siding.

About 9:00 a.m., three hazardous materials experts, who had been dispatched from Louisville by E. I. DuPont, arrived at the derailment site. By about 9:45 a.m., the hazardous material experts had stopped the leak from the contaminated vacuum relief valve on DUPX 20879.

Injuries to Persons

No one was injured.

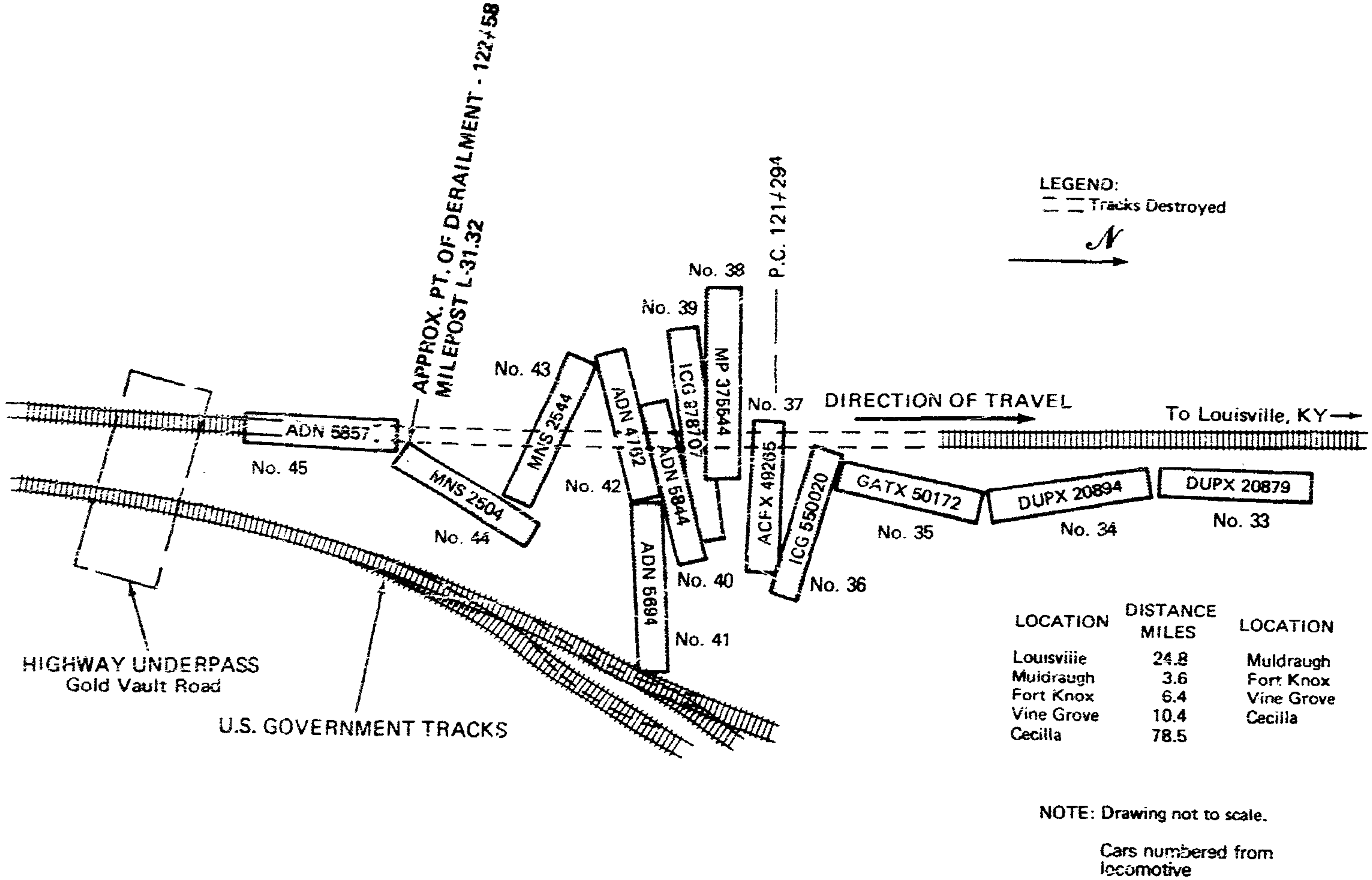

Figure 1.—Derailment of Illinois Central Gulf Freight Train, 1st No. 64, At Fort Knox, Kentucky on March 22, 2983.

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Figure 2.—Boxcar pile up at Fort Knox.
Direction of travel - right to left

Damage

Three tank cars, DUPX 20879, DUPX 20894, and GATX 50172, were damaged moderately. The degree of damage to the 10 boxcars ranged from moderate to severe. About 225 feet of track were destroyed and about 2 pole spans of signal wires were knocked down.

Equipment	$191,831
Track	7,500
Signal	500
Total	$199,831

Traincrew Information

The crewmembers of train 1st No. 64 had been called for duty at Central City at 10:45 p.m. on March 21, 1983. Each of the five crewmembers had had the required 8 hours of rest between tours of duty as prescribed by the Federal Hours of Service Law and was qualified for the position he held in accordance with ICG company rules. (See appendix B.)

Train Information

Train 1st No. 64 consisted of four locomotive units, Nos. 702, 8289, 8720, and 3005. Unit No. 702 was a former Gulf, Mobile and Ohio (GM&O) Railroad Company Model GP-38. Units Nos. 8289 and 8720 were rebuilt by ICG and identified as models GP-10 and GP-11, respectively, and unit No. 3005 was an ICG Model GP-40. Each unit was manufactured by the Electro-Motive Division (EMD) of General Motors Corporation and was equipped with a 26-L brake system and a multifrequency radio. The locomotive was not equipped with an alerting or dead man control device, or a speed or event recorder.

The loaded and empty cars were relatively evenly distributed throughout the train. Tank cars DUPX 20879 and DUPX 20894 were Department of Transportation (DOT) model 115A 60W6 insulated tank cars with a 21,200-gallon capacity; tankcar GATX 50172 was a DOT model 111A 100W5 tank car with a 20,573 gallon capacity. Each of the three tank cars was equipped with model CF 70 shelf couplers, but none of the cars was equipped with head shields. The inner tank of the tank-within-a-tank construction of the model 115-A tank cars was fabricated of fusion-welded alloy (stainless) steel and was not equipped with a dome. The space between the two tanks was insulated. Each of the 115A tanks cars was equipped with either a safety valve set to release at 35 psi or a safety vent set to release at 45 psi and a vacuum relief valve.

Scheduled train No. 64 was nicknamed the "chemical dispatch" because of the volume of chemicals (hazardous materials) moved by the train. During February 1983, 625 cars loaded with hazardous materials moved between Louisville and Paducah, Kentucky, over the Louisville District.

Method of Operation

Between Central City and Louisville, a distance of 123.7 miles, the ICG Railroad is designated as the Louisville district of the Midwest Division. Trains operate over the Louisville district by timetable, train orders, and the aspects of an automatic block signal system. Train 1st No. 64 was a second class 2/ northward train scheduled to depart Central City at 10:01 p.m. (on March 21, 1983) and to arrive in Louisville at 2:30 a.m. (on March 22, 1983).

The maximum authorized speed over the district for 1st No. 64 was 40 mph. Timetable special instructions rule 101(a) imposed a maximum speed of 30 mph between mileposts 25 and 41. No train, general, or bulletin orders specifically restricting the speed of the train through the vicinity of Ft. Knox were issued for 1st No. 64 on March 23, 1983.

Meteorological Information

At 4:34 a.m. on March 22, 1983, the weather at Fort Knox was: visibility—10 miles; temperature—35° F; light snow showers; and a slight breeze about 6 knots from the southwest. The relative humidity was about 66 percent.

Track

The single main track through Ft. Knox extends north and south. Beginning at milepost 32, the track is tangent northward for 377 feet, then curved for 763 feet through a 4° right curve, then tangent for 1,205 feet, after which it extends 1,375 feet to the point of a 2° left curve, which is not superelevated. The train derailed about 50 feet north of the beginning of the 2° curve.

The railroad grade northward beginning at milepost 33 descends at 1.75 percent for 1,005 feet, and then it is 0.0 percent for 750 feet. The grade then ascends at 1.25 percent for 1,255 feet, then descends at 0.21 percent for 5,270 feet and it is then level for 435 feet to the point of the derailment.

The 112-pound RE jointed rail is set on double shouldered 7"x13" tie plates which are laid on hard wood crossties. The track structure is built on 24 inches of crushed stone ballast. The American Railway Engineering Association (AREA) of the Association of American Railroads identifies the rail as: 11228 - RE OH ILLINOIS USA CC 630 616 F 18 1944 12 39 foot 6-hole joint. 3/

The rail was placed in service during 1944. The outside (curve) railhead was worn about 7/8 inch on the gage side and it was badly shelled. The railhead of a new 112-pound RE-rail measures 2 23/32 inches. Some typical wheel-rail contact configurations are shown in figure 3.

2/ The precedence or priority classification of a train assigned by timetable.
3/ 112.28 - Weight 112 pounds per yard
RE - Design Type (American Railway Engineering Association)
OH - Open Hearth
ILLINOIS USA - Steel Company
CC-Controlled cooling
630 - Furnace Number 63
616 - Heat Number (the number of consecutive heats for furnace, #63 for that year)
F - 6th cut of the ingot, thus the 6th rail
18 - Ingot Number
1944 - year rail was rolled
12 - Month rail was rolled
39 - 39 Foot Length
6 Hole Joint - 3 Holes per rail end

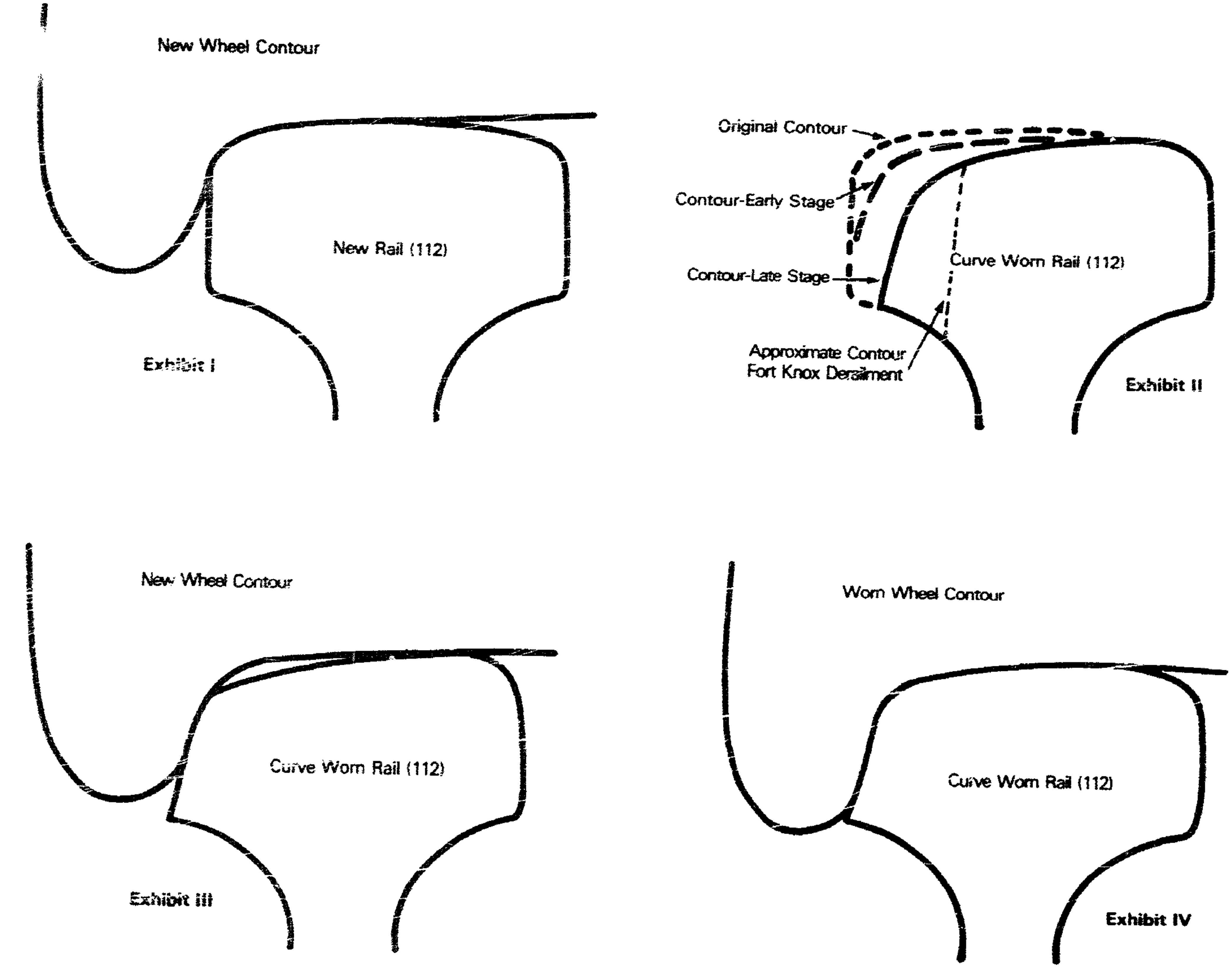


Figure 3.--Typical wheel-rail contact configurations.

A broken outside rail was found at the beginning of the exit spiral of the 2° left curve. (See figure 4.) The rail broke into six pieces, all of which were recovered, except for one short section. (See figures 5 and 6.) The first break occurred 29 feet from the south end of the rail. A detail fracture 4/ was evident at the first break and at least one other detail fracture was evident at another break.

Flange marks which were evident in the web of the rail just before the first break did not extend beyond that break. (See figure 7). A small batter mark was visible on the gage side of the rail across the first break. The broken rail was sent to the ICG Engineering Offices in Chigago, Illinois, for forwarding to the Association of American Railroads (AAR) laboratory in Chicago, for metallurgical analysis. However, after ICG engineering personnel examined the rail and determined that the defect was an obvious detail fracture, the rail was not forwarded to the AAR for further analysis.

According to ICG, the track is maintained to meet Federal Railroad Administration (FRA) Track Standards (49 CFR Part 213) for Class 3 track. (See appendix C.) Track inspections were conducted twice weekly from a hy-rail vehicle. The last gaging and cross level adjustments were performed on the track during February 1983. A Sperry Rail test car last tested the broken rail found at the derailment site on November 30, 1982, and no defects were reported.

Safety Board investigators reviewed track inspection records for the accident area for the period February 25, 1983 through March 21, 1983. The records noted missing bolts from track joints, defective heel blocks, and defective track frogs. One broken rail, for which no cause was shown, and two broken track joint bars had been replaced during that period.

Tests and Research

On March 30, 1983, the ICG ran a computer simulation of the movement of 1st No. 64 at Memphis, Tennessee. The parameters simulating train 1st No. 64 for the test were:

Area — Milepost 35 to milepost 31.32, the point of derailment.

Train Consist — 48 loaded and 30 empty cars, 6,295 net tons, 6,798 gross tons, 3,594 lading tons, and 4,566 feet in length.

Train Power — 8,500 horsepower, 1.25 hp/ton, 82 tons per brake, 0.17 net brake.

The simulated train was operated in the same manner described by the engineer operating train 1st No. 64 on March 22, 1983. The results coincided with the the speeds and events described by the engineer on the day of the accident. No excessive buff or draft forces were exhibited until the train began to derail.

4/ "A progressive fracture starting from a longitudinal separation close to the running surface of the railhead and then turning downward to form a transverse separation substantially at right angles to the running surface." Rail Defect Manual compiled by Sperry Rail Service, page 38.

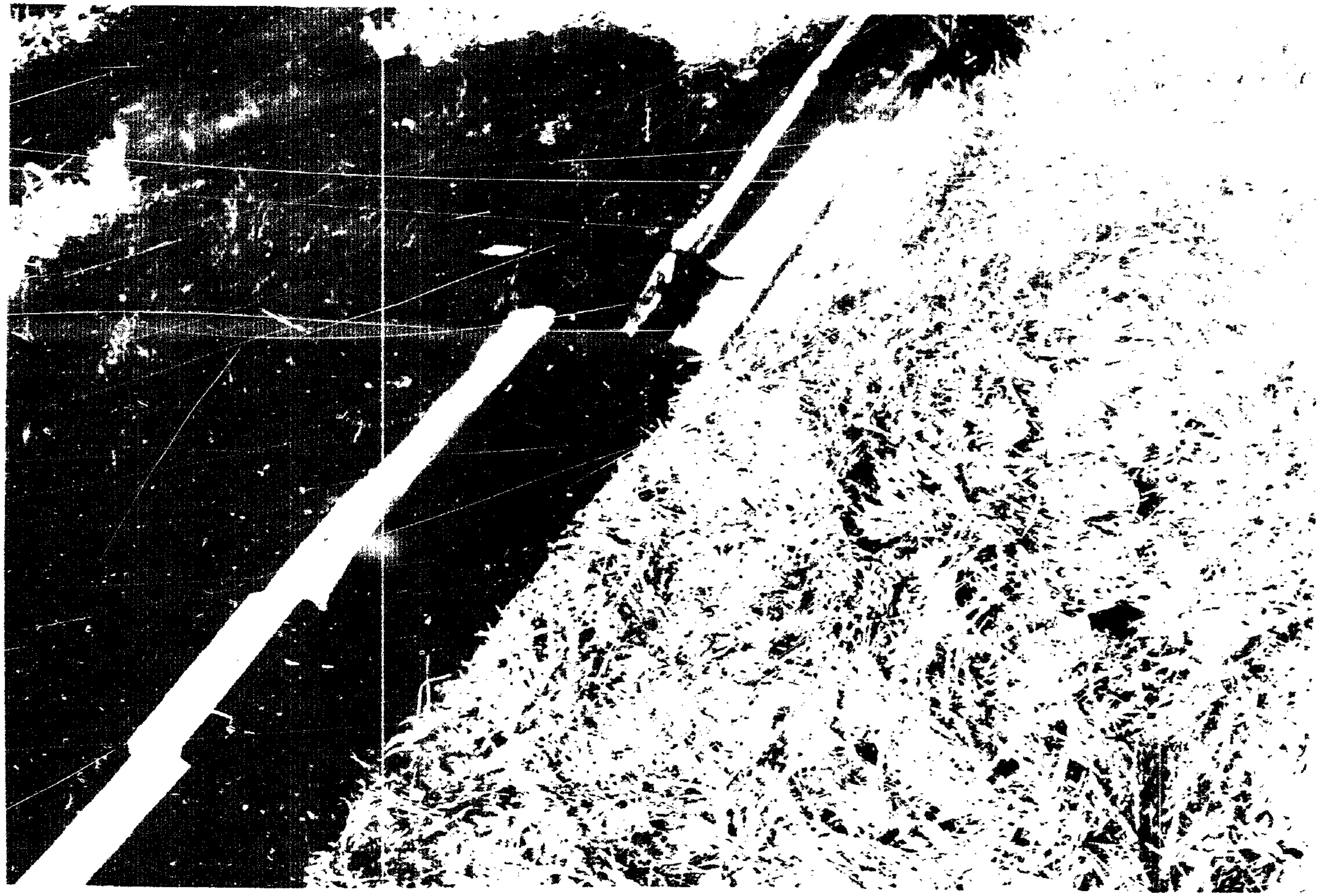


Figure 5.—Sections of broken rail. Direction of travel -- left to right. Gap is section of rail not found by investigators.

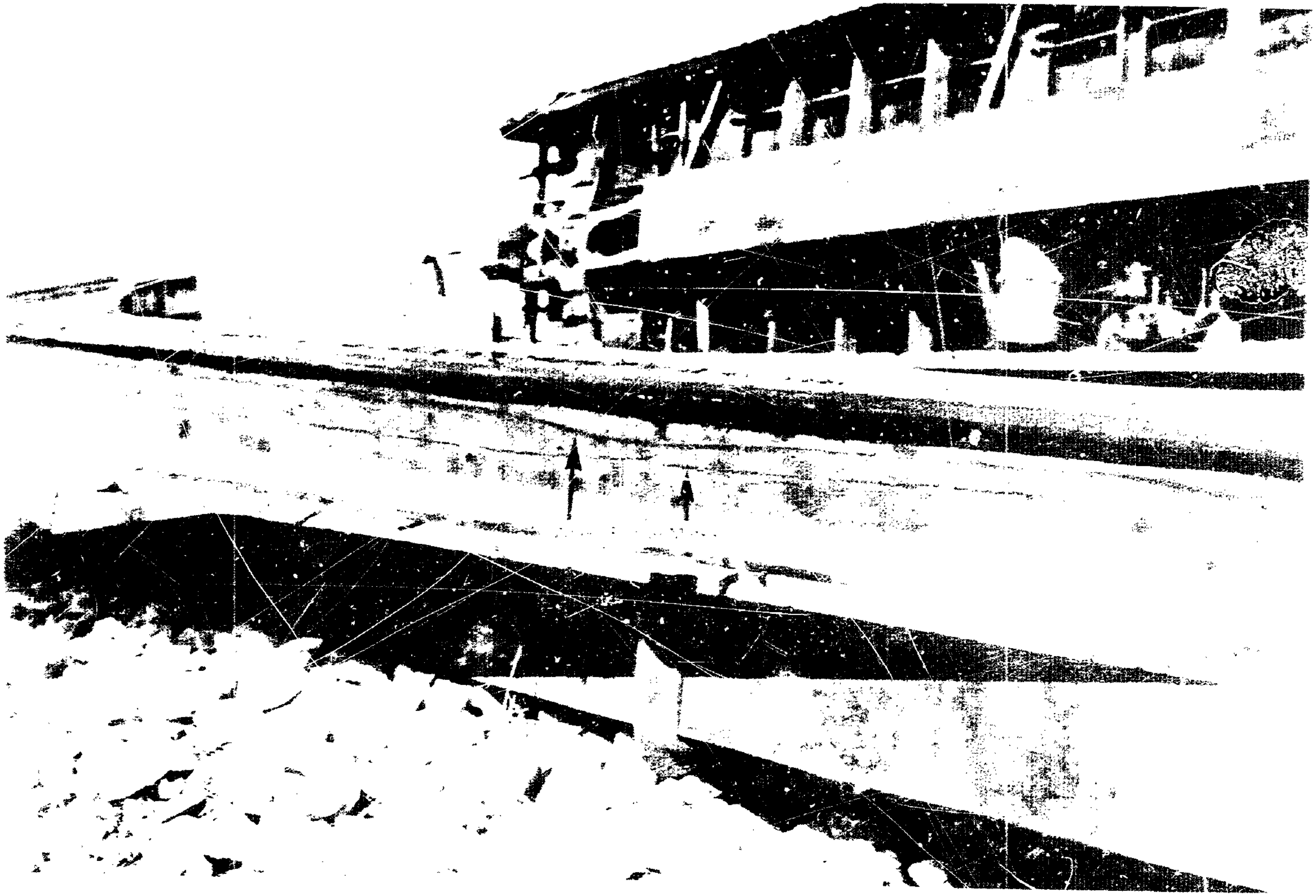


Figure 7.--Flange marks on web of broken rail ahead of first break.

On March 24, 1983, gage measurements and unloaded 5/ cross level checks were made at 20-foot intervals south of or in the approach to the first broken section of track at milepost L31.32. The following values were obtained:

Station	Cross Level (inch)	Gage (inch)	Station	Cross Level	Gage
1	3/16 +	56 3/8	11	1/2 -	56 5/8
2	1/8 +	56 3/8	12	5/8 -	56 5/8
3	1/4 -	56 3/4	13	5/8 -	56 5/8
4	1/8 +	56 1/2	14	1/4 -	56 5/8
5	5/16 -	56 1/2	15	1/2 -	56 3/4
6	5/16 -	56 1/2	16	1/2 -	56 3/8
7	3/16 -	56 1/2	17	3/8 -	56 5/16
8	9/16 -	56 1/2	18	5/8 -	56 3/8
9	1/8 -	56 1/2	19	1/4 -	56 7/16
10	5/16 -	56 5/8	20	3/8 -	56 3/4

+ indicates the east rail (outside curve rail) was high.
- indicates the east rail was low.

Further measurements of track parameters south of the derailment site disclosed two track joints that were too low to meet the maximum 0.75-inch allowable cross level deviation allowed by the FRA track standards for Class 3 track. After the accident, a Safety Board investigator found a broken joint bar at milepost 31 in the east rail on tangent track; the bar was replaced the same day.

ANALYSIS

Rail Breakage

The postaccident investigation revealed that the outside curve rail was excessively worn and was shelling. (See figure 8.) Experience indicates that shelling leads to detail fractures in the railhead and weakens the rail. Detail fractures are the result of the excessive contact stresses of heavy wheel loads repeated over a long period of time and, as such, are fatigue-related defects. The growth of a detail fracture from shelling occurs rapidly in contrast to other transverse fissures. The continued use of the worn rail led to shelling and the subsequent development of detail fractures.

The flange marks on the web of the rail stopped abruptly at the first break in the rail. The batter marks on the piece of rail further indicates that the rail broke initially at that point and allowed the wheels of DUPX 20879 to move to the outside of the rail. (See figure 6.) Apparently, when the wheel struck the railhead at the initial break, the impact force caused the rail to break at other points. Also when the rail broke, the unbroken rail reseated itself into position and provided usable rail for following cars. Wheel batter marks on portions of the railhead and web portions of other pieces of the broken rail indicate that the cars immediately following DUPX 20879 initially passed over the segmented rail and remained on the track until the emergency brake application. The broken rail then was displaced, and the following cars derailed.

5/ The weight of a locomotive or freight car will depress either the rail and/or crosstie to a firm bottom. When the weight is removed, the track will return to its unloaded position which is usually higher than its loaded position.

Investigators determined that the initial break in the outside curve rail was caused by lateral force on the excessively worn, shelly rail. The break occurred at a detail fracture which resulted from shelling. The progressive fracture started from a longitudinal separation close to the running surface of the railhead and then turned downward to form a transverse separation substantially at right angles to the running surface. (See figure 8.) According to the Sperry Rail Service's Rail Defect Manual, this condition is most frequently found on the gage corner of the railhead and is caused by metal flow at the gage corner of the head which breaks away and leaves a shallow cavity.

Through its twice weekly inspection program, upper level ICG supervisors should have been aware of the potential for rail failure which existed at the accident site, and the manager responsible for maintenance then should have adjusted the maintenance program to compensate for the condition of the track. Train speed around the curve should have been reduced until the worn and shelly rail was replaced and the cross level corrected.

It is particularly important to maintain good cross level and good rail on the outside curve when there is no superelevation to compensate for the lateral forces exerted by a train. When a train moves around a curve with or without superelevation, irregular cross level with low spots in the outside rail more rapidly tends to increase the lateral force applied to the outside rail of the curve.

Although the ICG's practice of maintaining 2° curves in main track without superelevation is not prohibited by American Railway Engineering Association (AREA) recommended practices, it is not a general industry practice. Former ICG curve superelevation requirements, which were replaced by those shown in appendix G, recommended 7/8-inch superelevation for a 2° curve over which trains were allowed to operate at 30 miles per hour.

When superelevation is not incorporated in a curve, the equilibrium speed, is at or near zero miles per hour. Therefore, when trains are operated through a curve with no superelevation, even at minimal speeds, rail condition and track geometry must be maintained at optimal values. The Safety Board believes that, in light of the stringent trackage maintenance requirements mandated by zero superelevation, the ICG should seriously consider the practice of elevating the outside rails of curves to compensate for less than optimal track conditions.

In the absence of superelevation in the 2° curve and because of extreme wear of the railhead at the derailment site, the resultant force of the rail cars would have been manifested in a manner that would have increased the outward force on the outside curve rail. (See figure 9.) Because of the 7/8-inch railhead wear, a vector diagram constructed at the railhead would show the vector resultant has moved outward on the railhead. Unless the wheel climbed over the rail (and there are no marks on the railhead to indicate it had) the shift of the resultant vertical and centrifugal forces from A to B on the rail would cause the rail to move laterally and/or to tip.

Superelevation permits the weight of the car to be used as a gravitational force to offset partially the centrifugal forces generated by the weight and the speed of a car around a curve. Ideally the resultant of the vertical and centrifugal forces will be a force at the centerline of the equipment and perpendicular to a plane formed by the tops of the two running rails. Such a resultant force is produced at the equilibrium speed for the curve and it represents an ideal condition. (See appendix D.)

Figure 5.-- End view of broken rail showing detail fracture and shelling.

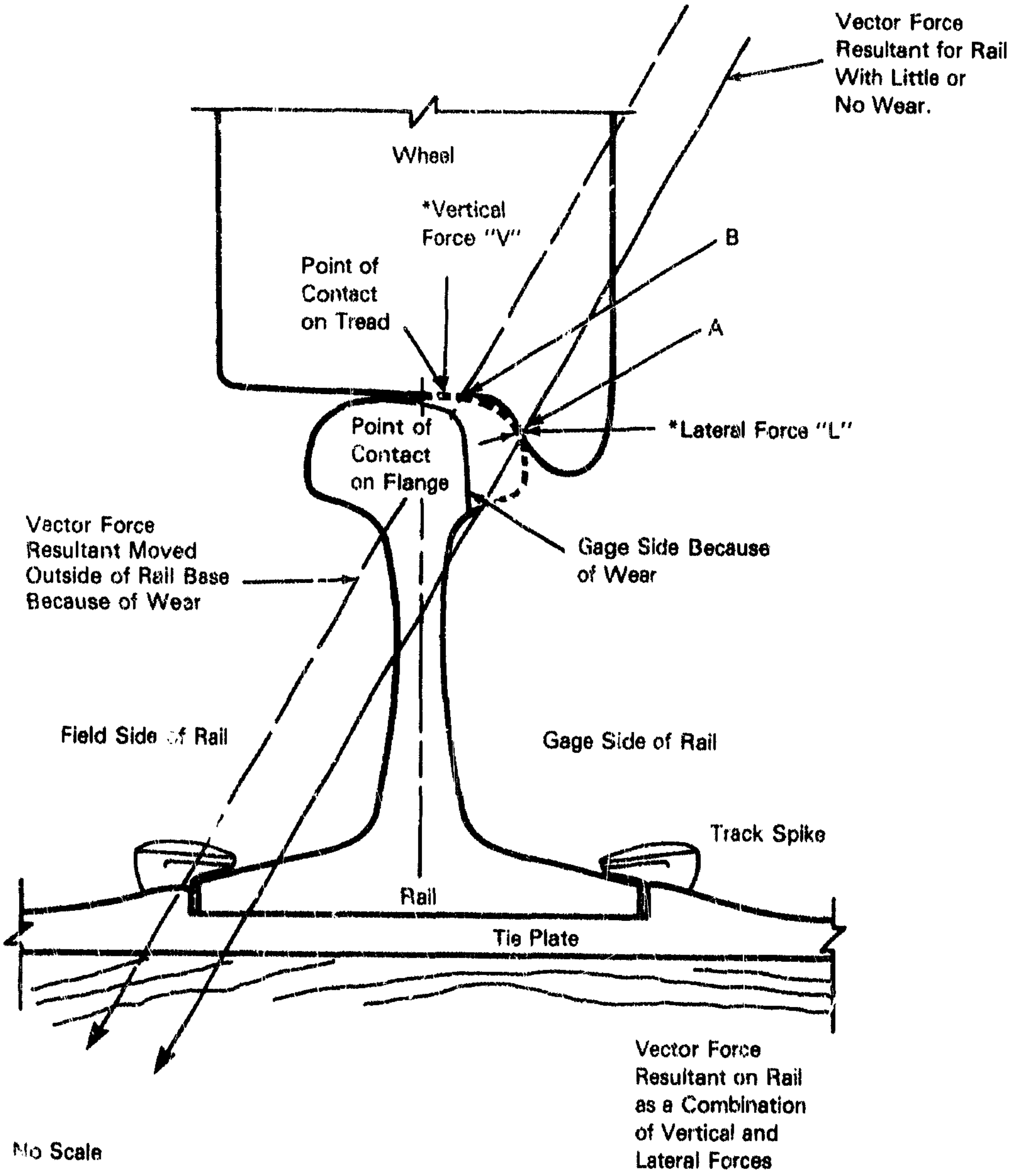


Figure 9.—Loading effect on rail.

When the equilibrium condition is not achieved, the combination and effect of other forces must be considered. The ratio of the lateral forces to the vertical forces imposed on the rails by rail equipment produces a measurable quantity identified as the $L/_V$ ratio. As the $L/_V$ ratio approaches unity, the probability increases for a wheel to climb up and cross over the railhead and for the rail to tip and/or move laterally. The rail will tip or move laterally at a lower $L/_V$ ratio than is required for wheel climb. (See appendix E.)

Based on the computer test run for train 1st No. 64 which indicated that there were no high buff forces present in the train just before the derailment, the centrifugal force exerted by the cars on the outside curve rail was solely the resultant force of the vertical and lateral forces of the cars. The postaccident cross level checks made in the approach to the first section of destroyed track indicated a variation in cross levels. Also, low joints were found in the track approaching the derailment site. Either or both conditions tend to vary the $L/_V$ ratio. A low joint in the outside curve rail would cause the $L/_V$ ratio to increase, i.e., move closer to unity and, thus, place added outward stress on the outside curve rail. Consequently, it becomes important that the track through a curve with no superelevation be maintained with no low joints or variations in cross level.

Accident History

On July 25, 1980, train No. 64, the "chemical dispatch," consisting of 4 locomotive units and 17 cars, including 7 placarded tank cars containing hazardous materials, derailed in a 6° curve at Muldraugh, Kentucky. 6/ The train derailed about milepost 26.6, located about 5 miles north of Fort Knox. (See figure 10.) Two tank cars transporting vinyl chloride were punctured, and the contents were ignited and burned. Four crewmembers received minor injuries in the derailment, and about 6,500 persons were evacuated from the surrounding area. The Safety Board determined that the probable cause of the accident was "the tipping of the outside rail and widening of track gage in the 6° curve because of the combined effects of defective crossties, excessively worn rail, irregular alignment and gage, and the lateral forces produced by the train's speed. Inadequate maintenance and inspection practices of the Illinois Central Gulf Railroad allowed these conditions to remain uncorrected. Contributing to the accident was the inadequate Federal Track Safety Standards which failed to provide for a track structure commensurate with the permitted train speeds."

Following the investigation of the Muldraugh accident the Safety Board recommended that the Illinois Central Gulf Railroad Company:

> Establish and implement procedures to maintain mainline tracks and sidings to a level of safety not less than that which is prescribed by Federal regulations governing carrier-designated track classes. (R-81-32)

On November 15, 1982, the ICG responded that a greater emphasis was being placed on track inspection programs and correction of defects by maintenance forces. The Safety Board accepted this action as responsive to the recommendation and classified it as "Closed—Acceptable Action." However, in the track near the site of the March 22, 1983, derailment, Safety Board investigators found low joints, loose track bolts, and a broken joint bar. Based on this evidence, the Safety Board believes the ICG management

6/ Railroad Accident Report—"Illinois Central Gulf Railroad Company Freight Train Derailment Hazardous Material Release and Evaluation, Muldraugh, Kentucky July 26, 1980" (NTSB-RAR-81-1).

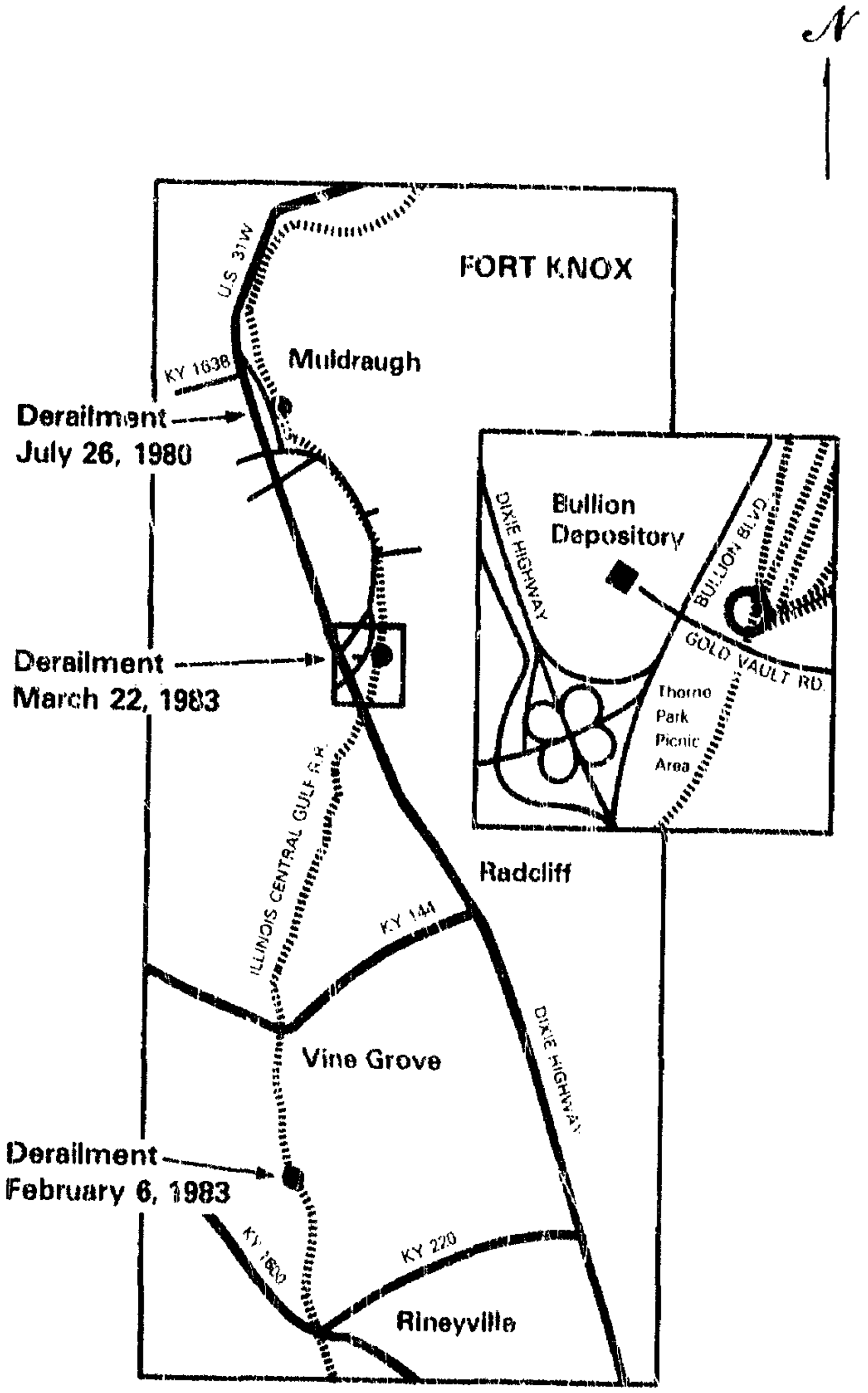


Figure 10.—Locations of derailments in the Fort Knox area.

has shown a lack of compliance with its own track inspection and maintenance programs. The fact that the railroad's actions are contradictory to its stated intent as set forth in the November 15, 1982, response is of great concern to the Safety Board. Therefore, the Safety Board is of the opinion that the thorough review of the qualifications of the ICG track inspectors, their lengths of assigned territories, and the methods used in inspecting the track is needed to be certain that an adequate inspection and maintenance program is ongoing which will improve the safety of train operations.

The ICG's track inspection procedures conforms to Section 213.233, Track Inspections, and section 213.235, Switch and Track Crossing Inspections, of the Federal Track Safety Standards. The Safety Board is aware that most or all of the major railroads conduct track inspections using either a hy-rail vehicle or a motor car traveling about 15 mph to detect track abnormalities. Although this procedure is allowed under the FRA's track safety standards, only easily visible or glaring defects, such as missing track bolts or a highly visible broken rail, can be detected from a moving vehicle. It may be coincidental, but ICG train derailments in the Fort Knox area occurred on track located between switches and track frogs which may indicate that because track inspectors are required to slow or stop the inspection vehicle for a standing inspection of these components the procedure produces better results. Therefore, the Safety Board believes that the ICG, and for that matter all railroads, can enhance their track inspection procedures by requiring track inspectors to systematically walk sections of the track, including areas through curves so as to observe track conditions more critically.

As a result of the Muldraugh accident, the Safety Board also recommended that the ICG:

> Establish and implement track maintenance standards which designate the limit of acceptable rail wear and which require rail removal when worn beyond the acceptable limits. (R-81-33)

On November 15, 1982, the ICG responded that it had issued Special Instruction T-10-82 entitled "Curve Worn Rail." (See appendix F.) Special instruction T-10-82 paragraph 3, Instruction, states the following:

> At such time as any track rail in main track service has worn to the extent that 1/4" of the design section metal has been removed at the gage line, the Track Supervisor shall notify the Division Engineering Manager in writing noting the following:
>
> 1. Location, by Mile Post to the tenth of a mile.
> 2. Wear at Gage Line.
> 3. Weight of Rail
> 4. Year Layed

The Safety Board acknowledged the issuance of Special Instruction T-10-82 and, based upon its content, believed that the ICG fulfilled the intent of recommendation R-81-33, even though the instruction did not specify that the worn rail be removed from service. Therefore, recommendation R-81-33 was classified as "Closed--Acceptable Action." During the investigation of the Fort Knox accident, however, ICG supervisory personnel who were asked about the instruction which specified the maximum allowable rail wear stated that they were not aware of the special instruction. Based on statements of supervisory personnel the Safety Board believes that the special instructions have not been widely circulated and that the importance of the instructions has not been brought to the attention of supervisory personnel and track inspectors that would ensure enforcement.

The curve rail at Fort Knox was worn about 7/8 inch which is over three times more than the 1/4-inch maximum wear allowed in Special Instruction T-10-82. As previously discussed in this report, wear on the rail head changes the design characteristics of the rail and its response to loading is different. Also, the current trend toward railroads' transporting heavier loads and using heavier locomotives places greater stress on lighter rails. The railhead wear exhibited on the curve rail at Fort Knox, indicated that the margin of safety was decreased and that the rail's load carrying capability was well below the limits imposed by the design criteria. Excessive wear also leads to shelling which is conducive to detail fractures. The Safety Board is aware that following the Muldraugh accident, the ICG implemented a program to replace excessively curve worn rails in the sharper curves on the Louisville District and that the curve rails with less curvature are to be replaced after work has been completed on the more severe curves. However, the Safety Board believes the ICG must expedite this program and urges it to replace curve worn rails without delay.

Also, as a result of the Muldraugh accident, the Safety Board recommended also that the FRA:

> Promulgate regulations which designate the limit of acceptable rail wear and which require railroads to remove from active tracks rails that are worn beyond the acceptable limits. (R-81-35)

On December 22, 1981, the FRA responded that since the gage measurement is specifically addressed in the existing track safety standards, defective gage conditions as defined should limit the rail usage relative to wear. The Safety Board however, interpreted the FRA's responses to mean that a rail in the outside of a curve could wear as much as 1 1/4 inches if there is no wear on the other rail. Because the Safety Board did not agree with the FRA's response, Safety Recommendation R-81-35 was classified as "Closed--Unacceptable Action." Adjusting the rail position to compensate for excessive wear on the gage side to maintain track gage within Federal requirements for the class of track involved, or turning the rail, 7/ does not fully cover the intent of Safety Recommendation R-81-35. The 7/8-inch wear on the rail in the curve was probably not considered detrimental by the ICG from an operating standpoint. However, the Safety Board believes it was detrimental from a load bearing standpoint. Increased wear, which causes a narrowing of the railhead and running surface, decreases the structural integrity of the rail and leads to other defects, such as shelling, which then makes the rail vulnerable to detail fractures. The Safety Board urges the FRA to reconsider the establishment of rail wear limit standards.

On February 6, 1983, 4 locomotive units and 27 cars in the "chemical dispatch" derailed in a 5° curve at Vine Grove, Kentucky, about 5 miles south of Fort Knox. No one was injured in the derailment. Five tank cars containing vinyl chloride and one tank car containing caustic soda were among the derailed cars. A small amount of caustic soda leaked from a dome area fitting of the car. Because of the involvement of the vinyl chloride, about 50 persons were evacuated from nearby residences as a precautionary measure. The Safety Board is investigating the accident, and although the probable cause of the derailment has not yet been confirmed, wide track gage is suspected. A broken rail believed to have been broken during the accident was found at the point of derailment.

7/ Positioning the rail in place 180° so the gage and field sides are reversed.

The track condition and volume of hazardous material on the route between Fulton and Louisville, Kentucky, warrants immediate attention to protect the public from the possibility of a catastrophic hazardous materials derailment. The ICG's actions in response to the Safety Board's recommendations in the Muldraugh accident report were not sufficient to prevent this derailment and the condition of the track raises concern about the possibility of future derailments. The potential for disaster is too great to continue moving hazardous materials over this route at speeds of up to 40 mph. The FRA should immediately impose speed restrictions on trains carrying hazardous materials on this route. It should make immediate onsite track inspections of the route and other routes of the ICG system which carry hazardous material to determine the condition of the tracks and impose such restrictions as may be indicated.

The Safety Board investigated an accident on the Southern Pacific Transportation Company (SP) at Thermal, California, which occurred January 7, 1982. 8/ The investigation disclosed several fractures near a rail joint. The railheads exhibited battering at the fractures, and it was noted that the railhead displayed shelly spots. Metallurgical analysis performed by the SP's testing facility determined that two of the fractures were detail fractures which originated from shelling. Detail fractures differ from other transverse defects because they are not the result of metallurgical factors, such as inherent inclusions 9/ in the rail steel. Rather, as described earlier in the analysis, they are the result of the excessive contact stresses of heavy wheel loads over an extended time frame and, as such, are fatigue-related defects. The growth of detail fracture from shelling occurs rapidly in contrast to other transverse fissures. Such phenomena should have been considered by the ICG management when it left the curve worn rail in service in the face of indications it had reached its service life limit. The continued in-service use of the worn rail subjected it to shelling and the subsequent development of detail fractures. As a result of the Thermal accident, Safety Recommendation R-83-14 was issued to the FRA on January 28, 1983, with the accident report.

In a letter dated July 29, 1983, the FRA responded to this safety recommendation and asserted that the Federal Track Safety Standards contained in 49 CFR 213 provided a detailed schedule of frequency and manner of inspecting track. The FRA further stated that 104 instructional classes had been conducted regarding track inspections as a part of FRA's regional inspection and enforcement activities. The Safety Board has historically been at odds with the FRA as to the adequacy of the guidance provided by the track safety standards. As stated by the Board on pages 21 and 22 of its report on the Thermal, California, accident,

> The prescribed remedial action depended on the track inspector's subjective determination of whether or not the condition required that the rail be replaced.

Safety Recommendation R-83-14 was issued with the intent of removing that subjective determination of rail condition. The track safety standards, as amended in September 1982, did not do this, and the FRA's response of July 29, 1983, is not considered acceptable as a response to R-83-14. Therefore, based on the circumstances of the Fort Knox accident, the Safety Board reiterates to the FRA Safety Recommendation R-83-14:

8/ Railroad Accident Report--"Derailment of Southern Pacific Transportation Company Train No. 01-BSNFF05 Carrying Radioactive Material at Thermal, California, January 7, 1982" (NTSB-RAR-83-1)

9/ A small quantity of gas or slag trapped in molten steel during the process of manufacturing rail which remains in the rail after it cools.

Develop, validate, and implement a model plan of recommended inspection practices containing clearly defined limits of allowable track structure conditions for the use of industry employed railroad track inspectors to facilitate uniform and knowledgeable appraisals of defective track structure conditions.

Train Operation

Train 1st No. 64 was being operated in accordance with ICG operating procedures and in compliance with authorized speed requirements. However, despite the work the ICG has done on the Louisville District, the track condition still appears to have been marginal for a Class 3 classification. Given the volume of hazardous material that is moved over the line, the Safety Board believes that the FRA should impose speed restrictions over the line until the track is made safe for the movement of hazardous materials. The potential for disaster is too great to continue allowing the movement of hazardous materials at speeds up to 40 mph over inadequately maintained track.

CONCLUSIONS

Findings

1. Train 1st No. 64 was being operated in accordance with ICG operating procedures and in compliance with its issued speed requirements.

2. The computer simulation of train operation verified that the handling of the train was as described by the engineer, and that the engineer's actions did not result in any unusual forces being applied to the track.

3. The train derailed as a result of irregular and unsafe track conditions and an excessively worn rail which broke at a detail fracture.

4. The rail tipped and was subjected to lateral stress forces before it broke at a detail fracture.

5. The wheel batter marks indicated that the cars immediately following DUPX 20879 initially passed over the segmented rail and remained on the track until the emergency brake application and the broken rail was displaced, allowing the following cars to derail.

6. The wear on the curve rail exceeded the maximum wear allowable by the ICG Engineering and Maintenance of Way Department.

7. Poorly maintained track contributed to two earlier derailments in the vicinity of Fort Knox within a 2 1/2-year period.

8. There is no Federal standard prescribing maximum allowable rail wear.

9. The present Federal Railroad Administration Track Safety Standards are not adequate to limit the use of head worn rails.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the tipping and breaking of an excessively worn, badly shelled curve rail at a point weakened by a detail fracture when it was subjected to normal outward lateral forces. Contributing to the tipping and breaking of the rail were the poorly maintained irregular cross level track and the absence of superelevation of the track on the 2° curve. Also contributing to the accident was the failure of the Illinois Central Gulf Railroad management to monitor adequately its track maintenance program and to effectively enforce inspection and maintenance procedures.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that:

--the Illinois Central Gulf Railroad Company:

> Expedite the program for the replacement of rails in curves and all rails that fall within the criteria established by the Chief Engineer Maintenance of Way Department set out in Special Instruction T-10-82. (Class II, Priority Action) (R-83-93)
>
> Reestablish the practice of superelevating main track curves where it has been discontinued. (Class II, Priority Action) (R-83-94)
>
> Upgrade the maintenance level of the track in the Louisville District to meet fully the Federal Railroad Administration's Track Safety Standards for Class 3 track. (Class II, Priority Action) (R-83-95)

--the Federal Railroad Administration:

> Immediately issue an emergency order to reduce the speed of all trains carrying hazardous materials in the Louisville District of the Illinois Central Gulf Railroad Company until a safe speed can be determined by the Federal Railroad Administration. (Class I, Urgent Action) (R-83-79)
>
> Immediately conduct a one-time emergency on-site inspection of the track in the Louisville District of the Illinois Central Gulf Railroad Company to assign the appropriate classes of track for that District. (Class I, Urgent Action) (R-83-80)
>
> Evaluate the adequacy of the Illinois Central Gulf track inspection program and take remedial action as necessary. (Class II, Priority Action) (R-83-81)

Conduct on-site spot checks of other routes of the Illinois Central Gulf Railroad Company which carry hazardous materials for defective track conditions and where warranted conduct a comprehensive on-site emergency track inspection and assign the appropriate class of track. (Class II, Priority Action) (R-83-82)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ G. H. PATRICK BURSLEY
Member

/s/ DONALD D. ENGEN
Member

FRANCIS A. McADAMS, Member, did not participate.

August 9, 1983

APPENDIXES

APPENDIX A

INVESTIGATION

The National Transportation Safety Board was notified of this accident by the National Response Center about 8:30 a.m. on March 22, 1983. A railroad safety investigator was dispatched from the Washington Headquarters, and he arrived at the scene about 6:00 p.m. The Federal Railroad Administration worked jointly with the Safety Board investigator during the investigation.

APPENDIX B

CREWMEMBER INFORMATION

Mr. Lindell Hughs Richey - Engineer

Mr. Richey, 57, was employed by the ICG as a locomotive fireman December 31, 1950. He was promoted to engineer during 1966. A review of Mr. Richey's employment record indicated a "clear" operating record. He passed his last medical examination in September 1982 (required at 4-year intervals), and his last operating rules examination during the summer of 1982.

Mr. Lyndell Eddie Reed, - Conductor

Mr. Reed, 44, was employed by the ICG as a switchman on October 31, 1957. He was promoted to conductor on December 15, 1964. A review of Mr. Reed's employment record indicated a "clear" operating record. He passed his last medical examination on September 11, 1981. His personnel record does not indicate the date of his last operating rules examination.

APPENDIX C

EXCERPTS FROM THE FEDERAL RAILROAD ADMINISTRATION'S TRACK SAFETY STANDARDS

SUBPART A – GENERAL

§ 213.1 Scope of part.

This part prescribes initial minimum safety requirements for railroad track that is part of the general railroad system of transportation. The requirements prescribed in this part apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from the requirements in this part, may require remedial action to provide for safe operations over that track.

§ 213.3 Application.

(a) Except as provided in paragraphs (b) and (c) of this section, this part applies to all standard gage track in the general railroad system of transportation.

(b) This part does not apply to track–

(1) Located inside an installation which is not part of the general railroad system of transportation, or

(2) Used exclusively for rapid transit, commuter, or other short-haul passenger service in a metropolitan or suburban area.

(c) Until October 16, 1972, Subparts A, B, D (except § 213.109), E, and F of this part do not apply to track constructed or under construction before October 15, 1971. Until October 16, 1973, Subpart C and § 213.109 of Subpart D do not apply to track constructed or under construction before October 15, 1971.

§ 213.5 Responsibility of track owners.

(a) Any owner of track to which this part applies who knows or has notice that the track does not comply with the requirements of this part, shall–

(1) Bring the track into compliance, or

(2) Halt operations over that track.

(b) If an owner of track to which this part applies assigns responsibility for the track to another person (by lease or otherwise), any party to that assignment may petition the Federal Railroad Administrator to recognize the person to whom that responsibility is assigned for purposes of compliance with this part. Each petition must be in writing and include the following–

(1) The name and address of the track owner;

(2) The name and address of the person to whom responsibility is assigned (assignee),

(3) A statement of the exact relationship between the track owner and the assignee,

(4) A precise identification of the track,

(5) A statement as to the competence and ability of the assignee to carry out the duties of the track owner under this part, and

(6) A statement signed by the assignee acknowledging the assignment to him of responsibility for purposes of compliance with this part.

(c) If the Administrator is satisfied that the assignee is competent and able to carry out the duties and responsibilities of the track owner under this part, he may grant the petition subject to any conditions he deems necessary. If the Administrator grants a petition under this section, he shall so notify the owner and the assignee. After the Administrator grants a petition, he may hold the track owner or the assignee or both responsible for compliance with this part and subject to penalties under § 213.15.

§ 213.7 Designation of qualified persons to supervise certain renewals and inspect track.

(a) Each track owner to which this part applies shall designate qualified persons to supervise restorations and renewals of track under traffic conditions. Each person designated must have–

(1) At least -

(i) 1 year of supervisory experience in railroad track maintenance; or

(ii) A combination of supervisory experience in track maintenance and training from a course in track maintenance or from a college level educational program related to track maintenance;

(2) Demonstrated to the owner that he–

(i) Knows and understands the requirements of this part,

(ii) Can detect deviations from those requirements; and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations, and

(3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements in this part.

(b) Each track owner to which this part applies shall designate qualified persons to inspect track for defects. Each person designated must have—

(1) At least-

(i) 1 year of experience in railroad track inspection; or

(ii) A combination of experience in track inspection and training from a course in track inspection or from a college level educational program related to track inspection;

(2) Demonstrated to the owner that he—

(i) Knows and understands the requirements of this part;

(ii) Can detect deviations from those requirements, and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

(3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements of this part, pending review by a qualified person designated under paragraph (a) of this section.

(c) With respect to designations under paragraphs (a) and (b) of this section, each track owner must maintain written records of—

(1) Each designation in effect;

(2) The basis for each designation; and

(3) Track inspections made by each designated qualified person as required by § 213.241.

These records must be kept available for inspection or copying by the Federal Railroad Administrator during regular business hours.

§ 213.9 Classes of track: operating speed limits.

(a) Except as provided in paragraph (b) & (c) of this section and §§ 213.57(b), 213.59(a), 213.105, 213.113 (a) and (b), and 213.137 (b) and (c), the following maximum allowable operating speeds apply:

Over track that meets all of the requirements prescribed in this part for—	*The maximum allowable operating speed for freight trains is—*	*The maximum allowable operating speed for passenger trains is—*
Class 1 track ..	10 m.p.h.	15 m.p.h.
Class 2 track ..	25 m.p.h.	30 m.p.h.
Class 3 track ..	40 m.p.h.	60 m.p.h.
Class 4 track ..	60 m.p.h.	80 m.p.h.
Class 5 track ..	80 m.p.h.	90 m.p.h.
Class 6 track ..	110 m.p.h.	110 m.p.h.

(b) If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements of this part. However, if it does not at least meet the requirements for class 1 track, no operations may be conducted over that segment except as provided in § 213.11.

(c) Maximum operating speed may not exceed 110 m.p.h. without prior approval of the Federal Railroad Administrator. Petitions for approval must be filed in the manner and contain the information required by paragraph 211.11 of this chapter. Each petition must provide sufficient information concerning the performance characteristics of the track, signaling, grade crossing protection, trespasser control where appropriate, and equipment involved and also concerning maintenance and inspection practices and procedures to be followed, to establish that the proposed speed can be sustained in safety.

SUBPART F – INSPECTION

§ 213.231 Scope.

This subpart prescribes requirements for the frequency and manner of inspecting track to detect deviations from the standards prescribed in this part.

§ 213.233 Track inspections.

(a) All track must be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under § 213.7.

(b) Each inspection must be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this part. However, mechanical or electrical inspection devices approved by the Federal Railroad Administrator may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 miles per hour when passing over track crossings, highway crossings, or switches.

(c) Each track inspection must be made in accordance with the following schedule:

Class of track	Type of Track	Required frequency
1, 2, 3	Main track and sidings.	Weekly with at least 3 calendar days interval between inspections or before use, if the track is used less than once a week, or twice weekly with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year.
1, 2, 3	Other than main track and sidings.	Monthly with at least 20 calendar days interval between inspections.
4, 5, 6		Twice weekly with at least 1 calendar day interval between inspections.

(d) If the person making the inspection finds a deviation from the requirements of this part, he shall immediately initiate remedial action.

§ 213.235 Switch and track crossing inspections.

(a) Except as provided in paragraph (b) of this section, each switch and track crossing must be inspected on foot at least monthly.

(b) In the case of track that is used less than once a month, each switch and track crossing must be inspected on foot before it is used.

§ 213.237 Inspection of rail.

(a) In addition to the track inspections required by § 213.233, at least once a year a continuous search for internal defects must be made of all jointed and welded rails in classes 4 through 6 track, and class 3 track over which passenger trains operate. However, in the case of a new rail, if before installation or within 6 months thereafter it is inductively or ultrasonically inspected over its entire length and all defects are removed, the next continuous search for internal defects need not be made until three years after that inspection.

(b) Inspection equipment must be capable of detecting defects between joint bars, in the area enclosed by joint bars.

(c) Each defective rail must be marked with a highly visible marking on both sides of the web and base.

§ 213.239 Special inspections.

In the event of fire, flood, severe storm, or other occurrence which might have damaged track structure, a special inspection must be made of the track involved as soon as possible after the occurrence.

§ 213.241 Inspection records.

(a) Each owner of track to which this part applies shall keep a record of each inspection required to be performed on that track under this subpart.

APPENDIX D

EXCERPTS FROM THE ASSOCIATION OF AMERICAN RAILROADS AMERICAN RAILWAY ENGINEERING ASSOCIATION

4.1.1.1.A SUPERELEVATION

Superelevation is the raising of the outer rail on a curve to permit using the weight (gravitational force) to counteract the effect of centrifugal force. Raising the outer rail moves the effect of the weight force toward the inside rail. Combining the effects of the centrifugal force and weight produces a resultant force as illustrated in Figure 6.

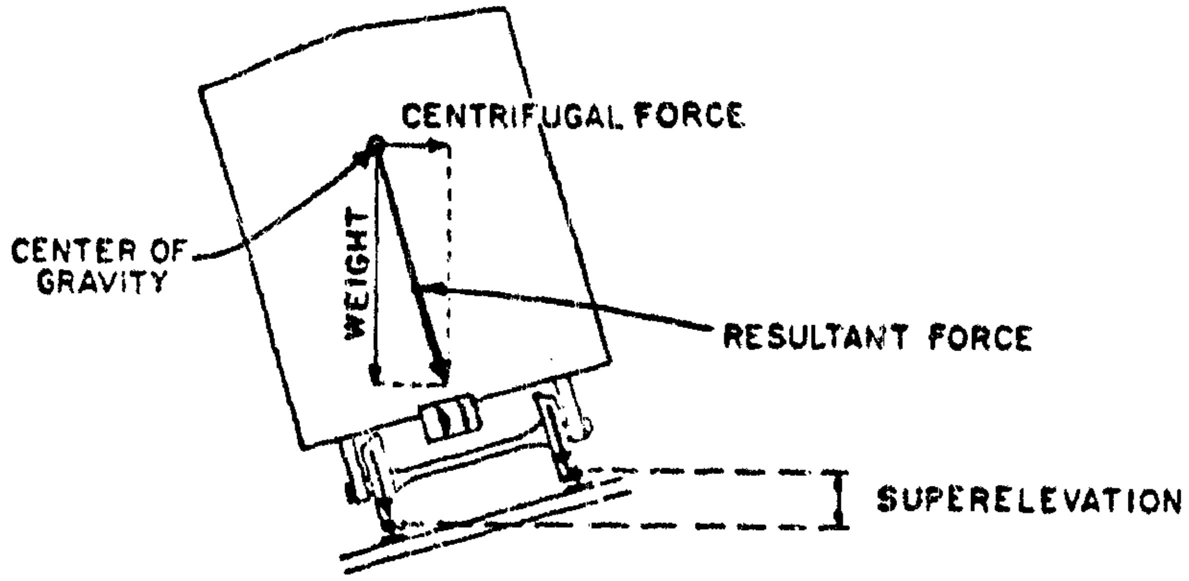


Figure 6. Superelevated Car In Equilibrium

When the direction of the resultant force coincides with the centerline of the equipment and track the curve is described as being balanced and equilibrium speed has been reached. In this condition the vertical forces on each rail are equal and minimal frictional forces are occurring between the wheels and the rail. This permits maximum utilization of tractive effort and minimum wear on wheels and rail. However, trains may operate at all speeds from the maximum allowable to a complete stop on a curve. Also, the consist may have many different types of cars with varying centers of gravity. Therefore, the design of superelevation of a curve and the speeds allowed must be carefully chosen. Insufficient superelevation may allow a car to climb the rail or overturn. However, railway equipment will generally "climb" over the rail due to lateral flange pressure and friction before the car will overturn. On the other hand, excessive superelevation may cause the wheels on the high rail to unload due to reduced vertical force and cause wheel lift.

Trains can operate around curves at speeds in excess of equilibrium with safety until reaching this point that wheel climb impends. The height of center of gravity becomes a major consideration when there is unbalance between speed, curvature and superelevation.

This is illustrated in Figure 7 which shows the approximate position of the dynamic resultant force of freight cars on curved track when traveling at speeds above 20 mph. As the center of gravity increases, less underbalance can be permitted.

It is recommended that the maximum speed permitted on a curve should not result in unbalanced superelevation beyond the limits where wheel climb impends.

When a train travels at less than the equilibrium speed around a superelevated curve there is an unbalance with the resultant force directed toward the inside or low rail. As more of the weight is carried by the low rail, there is an unloading of the outer or high rail. The extreme condition is for the low rail to carry the entire vertical force and the high rail to be completely unloaded. This is an unstable operating condition which can result in wheels lifting off the rail. Figure 8 illustrates the approximate position of the dynamic resultant force with overbalance to the low rail for a speed of 15 mph.

Figure 8 is based on lateral roll amplitudes running over track with normal irregularities. Equipment with 98 inch high center of gravity will not unload the high rail of well maintained track until the overbalance is slightly in excess of 6 inches. However, the "string line" effect of starting or pulling a drag train combined with overbalance effect may cause unloading of the high rail with less than 6 inches superelevation in the track.

When determining the superelevation of a curve, very slow operation and stopped condition must not be ignored. *WHERE PRACTICAL SUPERELEVATION SHALL BE PROVIDED FOR EQUILIBRIUM SPEED. OTHERWISE, IT IS RECOMMENDED THAT THE MAXIMUM SPEED OF THE 98" HIGH CENTER OF GRAVITY CARS (MAXIMUM HEIGHT CENTER OF GRAVITY ALLOWED IN FREE INTERCHANGE) BE RESTRICTED TO PROVIDE NO MORE THAN 2" UNBALANCE ELEVATION. A CURVE MUST NOT BE ELEVATED SO MUCH THAT UNLOADING OF THE HIGH RAIL MIGHT OCCUR AT VERY LOW SPEEDS OR WHEN STARTING.*

APPENDIX E

TRACK TRAIN DYNAMICS--TO IMPROVE
FREIGHT TRAIN PERFORMANCE

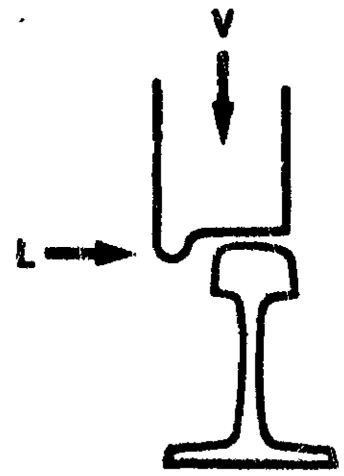
4.7 L/V Ratio

4.7.1 General

The ratio of lateral forces divided by the vertical forces is referred to as the L/V ratio.

Although it is necessary that the lateral and vertical forces, acting separately, be absorbed and restrained by the track structure, the effect of these two types of forces acting simultaneously, as illustrated in Figure 4-15, must be recognized.

Figure 4-15
Forces on Rail



Failure of some form may occur if the L/V ratio exceeds certain critical values. The ratio will increase if the lateral force increases and the vertical force remains constant, or if the vertical force decreases and the lateral force remains constant. High lateral forces are usually accompanied by high vertical loads which keep L/V ratios below critical levels. The highest L/V ratios most often occur because of a sudden reduction in vertical load.

The prevailing dynamic conditions associated with the vehicles, trucks and track will determine if a particular L/V ratio is critical. For example, L/V ratios that represent a problem in low-speed draft situations are not the same as those that may be a problem in high-speed buff situations.

L/V ratios are especially important in predicting wheel climb and rail turnover. The duration of the occurence will determine if the ratio is critical. An accepted duration for wheel climb or rail turnover to occur is in the order of 0.3 seconds.

*A publication from a joint effort by the Association of American Railroads, the Federal Railroad Administration, the Railway Progress Institute, and the Transport Canada Research and Development Center -- 2nd Edition R-185.

An L/V ratio in the order of 0.8 to 0.9 is generally considered a minimum for wheel climb to be likely. L/V ratios in excess of double these have been observed but because of their short duration, wheel climb did not occur.

The ratio of total lateral load on one side of a truck to total vertical load on the same side of the truck may cause rail roll-over at a lower L/V ratio than for an individual wheel to climb. On many common North American rail sections it can be shown that an unrestrained rail would overturn at a ratio of approximately 0.65. Of course, this figure can be exceeded in practice at a single wheel because the weight on adjacent wheels and the torsional stiffness of the rail helps hold the rail down, and also because of the hold-down power of the heads of the track spikes on the gage side. The lateral stability of the rail is further influenced by longitudinal forces that may be present, including tractive or braking forces imparted by the wheels and/or thermal stresses.

High L/V ratios of significant duration can occur when locomotives or cars bounce, pitch or roll. All vehicles have natural oscillation frequencies which, in combination with track irregularities, can cause vehicle instability at critical speeds. Bounce and/or pitch are vertical oscillations of the vehicle while roll or harmonic motion is a side-to-side rocking motion.

Although as already noted, harmonic roll occurs at relatively low speeds, vehicle instability due to vertical bounce and pitch are usually associated with speeds in excess of 50 miles per hour.

4.7.2 Effect of Variation in Surface

Vertical bouncing is initiated by abrupt sags or humps in track such as may occur at bridge ends, railroad crossings or soft spots in the track. The dynamic increases in vertical load due to bounce accelerate wheel and rail wear while the decrease of wheel loading may result in high L/V ratios.

To prevent possible uncoupling or binding of equipment and to minimize slack action, short, sharp vertical curves in the track structure should be avoided.

4.7.3 Effect of Variation in Cross Level

Variations in cross level may cause a side-to-side sway of a car which in turn results in transfer of weight from one rail to the other. If the vertical load on one rail is decreased in this manner while the lateral load remains constant, then the L/V ratio increases. Variation in cross level may cause reduced vertical loads on diagonally-opposite wheels of a truck, increasing the L/V ratio at those two wheels. In similar manner, abnormal variations in cross level within the limits of the distance between truck centers may result in high L/V ratios at the wheels on diagonally-opposite corners of the car.

4.7.4 Effect of Wide Gauge

It has already been noted in the discussion of lateral forces in Section 4.6.2 that wide gage allows greater skew of the truck. The resulting greater angle of attack between wheel flange and the rail increases lateral forces and the tendency for the wheel to climb the rail. This is especially so in curves, where the leading wheel of the truck normally is already exerting a heavy outward load on the outer rail. Although the lateral force may be abnormally high, the L/V ratio will remain within safe limits if the vertical wheel load is sufficiently high. If the vertical wheel load is significantly reduced for any reason while the high lateral force is occurring, and if the resulting high L/V ratio is maintained for a sufficient time period, wheel climb may occur.

On curves, if the outer rail is heavily worn the likelihood of wheel climb is increased, particularly if the wheel contour is in near new condition.

APPENDIX F

NOTICE ISSUED BY THE ICG TO ESTABLISH RAILWEAR LIMITS

ILLINOIS CENTRAL GULF RAILROAD COMPANY
OFFICE OF VICE PRESIDENT AND CHIEF ENGINEER

SPECIAL INSTRUCTION T-10-82

CURVE WORN RAIL

1. DESCRIPTION

This Special Instruction shall advise procedure in the event of curve worn rail.

2. SUPERSEDENCE

This Special INstruction supersedes all previous instruction on the matter.

3. INSTRUCTION

At such time as any track rail in main track service has worn to the extent that 1/4" of the design section metal has been removed at the gage line, the Track Supervisor shall notify the Division Engineering Manager in writing noting the following:

1. Location, by Mile Post to the tenth of a mile.
2. Wear at Gage Line.
3. Weight of Rail
4. Year Layed

4. ACTIONS

A. Track Supervisor shall issue appropriate slow orders
B. Division Engineering Manager shall notify the Engineer - Maintenance of Way in writing of the Track Supervisors report and action.
C. Engineer - Maintenance of Way and Division Engineering Manager shall determine necessary corrective action.

APPENDIX G

SUPERELEVATION TABLE ISSUED BY ICG TO GOVERN CURVE ELEVATION

DEGREE OF CURVE	SPEED IN MILES PER HOUR														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
0°30'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0°45'	0	0	0	0	0	0	0	0	0	0	0	0	1/4	3/4	1 1/4
1°00'	0	0	0	0	0	0	0	0	0	0	1/2	1	1 1/2	2	2 3/4
1°30'	0	0	0	0	0	0	0	1/4	3/4	1 1/2	2 1/4	3	3 3/4	4 1/2	
2°00'	0	0	0	0	0	0	1/2	1 1/4	2	3	4	5			
2°30'	0	0	0	0	0	1/2	1 1/2	2 1/4	3 1/4	4 1/2					
3°00'	0	0	0	0	1/4	1 1/4	2 1/4	3 1/4	4 1/2						
3°30'	0	0	0	0	1	2	3 1/4	4 1/2							
4°00'	0	0	0	1/2	1 1/2	2 3/4	4								
4°30'	0	0	0	3/4	2	3 1/2	5								
5°00'	0	0	1/4	1 1/4	2 1/2	4									
5°30'	0	0	1/2	1 3/4	3 1/4	4 3/4									
6°00'	0	0	3/4	2 1/4	3 3/4										
7°00'	0	0	1 1/2	3	5										
8°00'	0	1/2	2	4											
9°00'	0	1	2 3/4	4 3/4											
10°00'	0	1 1/2	3 1/4												
11°00'	0	1 3/4	4												
12°00'	1/2	2 1/4	4 1/2												

Superelevations must not exceed 5" without special permission from Engineer Maintenance of Way.

$E = 0.0007 V^2 D - 3$

E = Superelevation (inches)

V = Speed (M.P.H.)

D = Curve (decimal degrees)

REVISIO

DATE: May 22, 1980	DRWG. NO. 6/5
SCALE: None	FILE NO. E-3107