SP-20
Log R-493

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: March 6, 1985

Forwarded to:

Honorable John H. Riley
Administrator
Federal Railroad Administration
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-85-10 and 11

Since 1969, the National Transportation Safety Board has investigated seven major railroad accidents caused by track failure under dynamic loads and involving track geometry parameters such as gage, profile, alignment, and crosslevel not being maintained to the minimum standards set by the Federal Railroad Administration (FRA). (See Figure 1 for definitions and diagrams of the principle track geometry parameters.) These accidents resulted in 12 deaths, 349 injuries, and property damage of more than $4.6 million. Additionally, from January 1978 through December 1983, the Board completed 181 field investigations of accidents in which track was not maintained to design standards. These accidents resulted in 8 fatalities, 170 injuries, and estimated railroad property damage exceeding $63.1 million.

Accident statistics reported by the railroad industry to the FRA reveal that improper track geometry caused about 19 percent of all railroad accidents from 1978 until 1983 -- the single greatest cause of train accidents during the last 5 years. (See Table 1.) Nearly 99 percent of the accidents caused by improper track geometry result in a derailment. During 1981, 1982, and 1983, railroads reported to the FRA property damage losses of greater than $90 million from accidents caused by improper track geometry. Further, in 1981, 1982, and 1983, about 277 consists 1/ carrying hazardous materials were involved in train accidents caused by defects in track geometry.

In 1977, concerned about accidents caused by track deficiencies, the Safety Board recommended several actions regarding improvements in the track geometry standards themselves. However, the FRA repeatedly declined

1/ The information for 1981 and 1982 is found in FRA's Accident/Incident Bulletins, Nos. 150 and 151, Table S10A, "Train Accidents Involving Hazardous Materials by Cause." The information for 1983 was obtained by telephone conversation with FRA's Office of Safety.

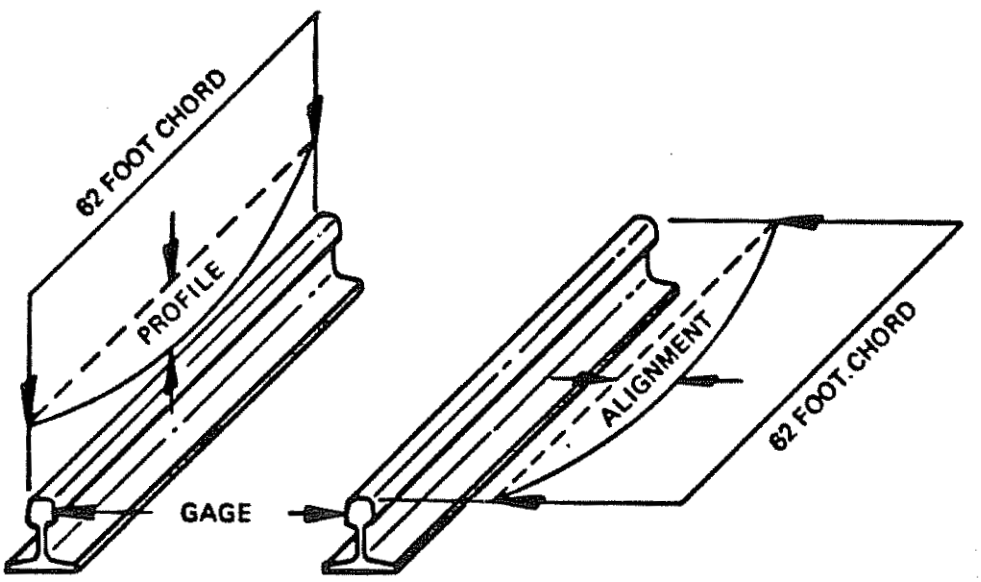
Figure 1. Definitions and Diagrams of Track Geometry Parameters used by the Federal Railroad Administration

The track geometry parameters measured by FRA track geometry cars are:

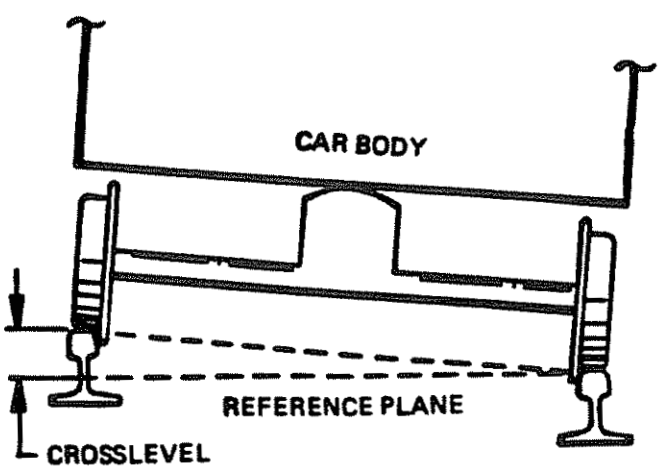
- Gage - the distance between the two rails in a track structure measured at five-eighths of an inch below the top surface of the rail.
- Profile - the measurement of the surface uniformity of each rail.
- Alignment - the measurement of the line uniformity of each rail.
- Crosslevel (Superelevation) - the difference in elevation between the left and right rails.
- Curvature - the measure of the angular rate of change in track direction.
- Warp or twist - the change in crosslevel over a defined distance.

The following diagrams illustrate how the track geometry parameters are measured by the FRA track geometry cars.

Gage, Profile, and Alignment



Crosslevel



Curvature

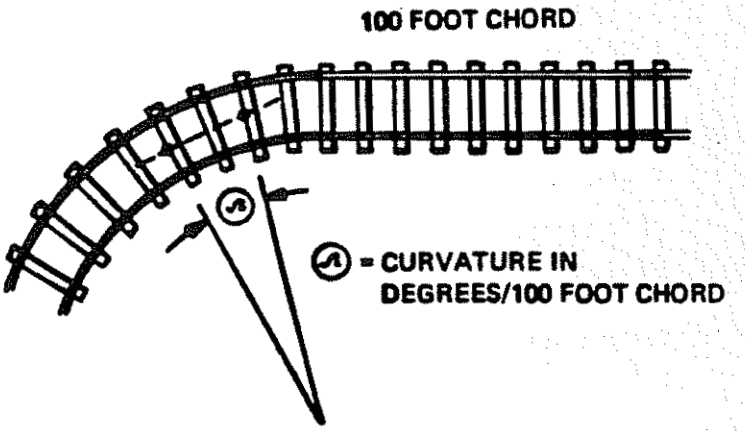


TABLE 1. Federal Railroad Administration Accident Statistics
As Reported By the Railroads (Calendar Years 1978 to 1982)

Year	Total Railroad-Reported Accidents	Track-Caused Accidents*	Track-Caused as Percent of Total Accidents	Track Geometry-Caused Accidents	Track Geometry-Caused as Percent of Track-Caused Accidents	Track Geometry-Caused as Percent of Total Accidents
1978	11,277	4,797	42.5	2,227	46.4	19.7
1979	9,740	4,050	41.6	1,894	46.8	19.4
1980	8,451	3,492	41.3	1,575	45.1	18.6
1981	5,781	2,273	39.3	1,048	46.1	18.1
1982	4,589	1,769	38.5	751	42.5	16.4
1983	3,906	1,581	40.5	717	45.4	18.4
Totals:	43,744	17,962	Average: 41.1	8,212	Average: 45.7	Average: 18.8

* Includes track, roadbed, and structures

to revise the standards, and in November 1982, the Board closed those and other related recommendations to the FRA and classified them "Unacceptable Action." Apart from the standards themselves, the Board continued to express concern about the potential for a catastrophic railroad accident involving hazardous materials and/or harm to rail passengers and train crewmembers from undetected deficiencies in track geometry.

In 1979, the Safety Board issued a Safety Effectiveness Evaluation report, "The Federal Railroad Administration's Hazardous Materials and Track Safety Programs." The Safety Board briefly reviewed the FRA's automatic track inspection program and recommended that it include goals and objectives and measurable criteria for program evaluation (R-79-20, issued March 20, 1979).

The FRA replied on October 12, 1979, that it had received funding for a comprehensive evaluation of the railroad safety program, including track standards and inspections. The FRA indicated the Transportation Systems Center (TSC) in Cambridge, Massachusetts, would review the factors believed to cause accidents and rank the severity of safety problems, using a Hazard Analysis and Priority Determination System. The FRA then would develop and implement alternative safety measures. The Hazard Analysis and Priority Determination System has never materialized. However, the FRA did publish a study, "A Prototype Maintenance-of-Way Planning System," FRA/ORD-80-47.1, Volume 1, in November 1980. In it the FRA developed a candidate series of 14 indices of track condition and degradation. These Track Quality Indices (TQIs), based on track geometry parameters such as gage, profile, alignment, crosslevel, and warp, could be measured by the FRA automated track inspection vehicles, which collect more than 36,000 data points per mile.

The FRA found that five of the 14 TQIs were best for quantifying track condition (or its degree of degradation from the standards) because they correlate positively with deviation from the Federal Track Safety Standards and with derailments due to unsafe track conditions. As stated in an FRA research study:

> TQIs have been found to correlate with track related derailments. That is, those segments of track for which derailments were reported possessed values of TQIs above the expected posted class value . . . .

Based on these five indices -- a line index, two gage indices, and two surface indices -- the FRA study developed equations which could predict the degradation in the condition of track which was not maintained to standards. The equations were found to account for at least 80 percent of the change observed in the tested track during 1 year, with a better than 99.9 percent level of confidence. 2/

2/ In a paper presented before the Transportation Research Board in January 1983, further FRA-contracted research on track quality indices indicated that five surface-related TQIs "relate to the ability of track to perform its functions." Alan J. Bing and Arnold Gross, "Development of Railroad Track Degradation Models," Transportation Research Record 939, Transportation Research Board, 1983.

While FRA has developed a method for predicting with high confidence the probable condition of track for the next year or two based on data obtained by automated track geometry vehicles, it has not developed a program to use these assessment/prediction methods regularly and systematically to assess the overall safety of the Nation's track system.

The Southern Railway System also has developed a method of using automated track inspection data which it described in a paper prepared in 1982, "Application of Track Geometry Information on the Southern Railway." 3/ The Southern program measures six track geometry parameters every 2 feet along the track, producing more than 15,000 data points. Southern uses track geometry data: (1) to identify specific track sites or locations where prompt corrective action is necessary to avoid imminent derailment; (2) to identify track segments for programmed or systematic gang maintenance; and (3) for use as a research and analytical tool (for example, to evaluate alternative maintenance-of-way techniques such as the use of a track-lining machine working alone without maintenance work gangs, thereby reducing maintenance-of-way costs).

Using 5 years of derailment data and about 7 months of track geometry data covering about 7,000 miles of track (about 70 percent of Southern's track system), Southern determined that the single track geometry parameter, profile, correlated highly with track-caused derailments. Southern also found a high correlation between track under slow order because of track problems and the track geometry parameter, warp. A third adverse factor Southern found associated with track geometry was rail flaws detected in new welded 132-pound rail. Analysis of data collected over 1 year indicated the rail flaw defect rate in 132-pound rail was highly correlated with out-of-tolerance track geometry parameters, specifically alignment, gage, and degree of curvature.

Southern's Manager of Quality Control Engineering stated: "It is clear that track geometry data can be effectively used in decision making in a broad range of maintenance-of-way applications. The industry is on the threshold . . . of a new era in track condition measurement . . . ."

The FRA used four automated track geometry inspection vehicles to inspect approximately 70,000 miles of track in each of the calendar years 1980 and 1981. In 1982, the FRA's automated track inspection program essentially was discontinued, and only 11,000 miles of track were inspected with automated vehicles. In 1983, the FRA inspected about 44,000 miles of track with two vehicles. The other two vehicles were leased, one to Conrail and one to Amtrak. Amtrak made no inspections with the leased vehicle in 1983. Conrail used its leased unit very little, and subsequently it was leased by FRA to another railroad.

Despite the FRA's intensive use of automated track geometry vehicles to inspect a substantial amount of track in the early 1980's and the availability of methodologies for using the inspection data to good effect, the FRA had no comprehensive program at the time for using the data and applying the methodologies.

In January 1983, the FRA's Office of Safety published "Railroad Safety National Inspection Plan 1983," the purpose of which was to describe the implementation of the FRA safety program by the regional safety offices.

3/ American Railway Engineering Association, Committee 32, Systems Engineering Newsletter, Volume 3, Number 2, August 1982.

It identified a set of annual objectives and discussed how the Office of Safety expected to achieve them. In that plan, five of the eight FRA regional safety offices were to put FRA automated track geometry vehicles into use. The use of automated track geometry inspection on routes regularly travelled by trains carrying either hazardous materials or passengers would allow the regional offices to monitor the railroads' track safety programs and to detect serious track geometry defects needing immediate correction to avoid derailments. It was reported that in one FRA region:

> The operation of the automated track geometry trains in past years has enabled several railroads in the Kansas City Region to locate and correct serious track defects on AMTRAK and hazardous materials routes prior to an accident. Several of these defects had been overlooked by the railroad's track inspection force and were so serious that the railroad removed the track from service until the repairs were complete. We believe these surveys to be of benefit to railroad safety and would like to see ATIP surveys made when funds are available 4/

The FRA has not published a 1984 plan, nor has it released the results of the monitoring and enforcement programs outlined in its 1983 plan.

On April 30, 1984, the FRA in responding to Safety Recommendation R-79-20, indicated that "automated track inspection will have a continuing role in improving track safety." The FRA stated that goals and objectives for one vehicle have been established "which include inspection of about 20,000 miles of passenger and high hazardous material routes per year...."

On August 8, 1984, following a number of highly visible Amtrak accidents, the Administrator announced that the FRA would increase its use of automated track inspection, including inspection of 22,000 miles of track used by Amtrak. This inspection program is now underway, but it is not clear that it involves more than a one-time inspection or that the FRA will continue to use automated equipment to monitor track safety systematically and regularly.

The Safety Board believes that railroad safety would be improved if the FRA were to pursue an annual track inspection program such as that outlined in Exhibit E of its "Railroad Safety National Inspection Plan 1983" (see Attachment 1), using its automated track geometry inspection capabilities on a regular and systematically programmed basis. There are sufficient vehicles to obtain the necessary data since the vehicles owned by the FRA and 14 railroads are not fully utilized and could be leased by railroads that do not have the equipment. 5/ What remains to be done is that the FRA

4/ Office of Safety, Federal Railroad Administration, Railroad Safety National Inspecton Plan, 1983. January 1983, Washington, D.C.

5/ In addition to FRA's vehicles, automated track geometry vehicles are operated by 14 Class I railroads and/or railroad systems. Although all of these inspection vehicles are used from time to time in maintenance programs to monitor the immediate condition of track, most of the railroads do not use their cars in a regular and systematic program to obtain data for evaluating track deterioration trends.

require the railroads to develop and implement a systematic and structured program to use automated track geometry inspection vehicles to obtain data and, using existing methods (such as TQIs), to determine when track maintenance work is necessary to maintain track at the highest level of safety. The Safety Board believes that such a formal and systematic program should be incorporated initially into the railroads' on-going track inspection programs of routes regularly travelled by trains carrying either hazardous materials or passengers.

Further, the Safety Board believes that the FRA must monitor compliance and enforce the national track safety program particularly on routes regularly travelled by trains carrying either hazardous materials or passengers, through the increased use of its automated track geometry inspection vehicles, so that all such track is inspected at least once a year using these vehicles. The use of the data objectively measured by the vehicles would greatly improve surveillance by the eight FRA regional safety offices. The FRA, thereby, could provide a technical audit of the railroads' track inspections that use automated track geometry vehicles, to ensure the accuracy of the railroads' equipment and to gage the extent to which the track safety program is being implemented by the railroads.

Additionally, automated track geometry inspection data should be used as an integral part of FRA's Office of Safety Headquarters' overall system safety evaluations of various railroads, and the results of these evaluations and followup actions taken by the FRA, such as the current Amtrak review, should be published. This would allow the Congress, the Safety Board, other safety organizations, and the interested public to be better informed regarding the safety of the Nation's railroad track system.

Therefore, the National Transportation Safety Board recommends that the Federal Railroad Administration:

Develop and implement a national track inspection program which requires railroad companies to use automated track geometry measurement systems in an on-going, systematic program of inspection of all routes emphasizing initially routes regularly travelled by trains carrying either hazardous materials or passengers. (Class II, Priority Action)(R-85-10)

Increase the use of automated track geometry inspections in its evaluations of railroad track systems and integrate the results of automated track geometry inspections into regional surveillance and enforcement programs, emphasizing initially routes regularly travelled by trains carrying either hazardous materials or passengers. (Class II, Priority Action) (R-85-11)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

by: Jim Burnett
Chairman

EXHIBIT E

EXPECTED TRACK ACTIVITY FREQUENCIES

BY REGION FOR 1983

ACTIVITY		REGIONS								
		1	2	3	4	5	6	7	8	ALL REGIONS
REGULAR	MAIN LINE (MILES)	32000	36325	35700	44484	32100	42500	18000	20000	261109
	YARDS (MILES)	800	2419	2100	3480	1900	1900	3000	800	15689
FEDERAL ASSIST. PROJ.		6	3	10	4	3	4	4	12	46
TECHNICAL METTINGS		15	18	14	20	4	20	8	4	103
GOV. OWNED TRACK		4	4	10	0	150	3	10	2	183
OTHER		12	0	0	0	2	5	9	-	28
RECORDS		180	354	250	382	1000	272	50	175	2663

Attachment 1