Rail Defect Type vs. Derailment Risk

Recent research activities have addressed the relationship between rail defects and derailments.[1] Included in these investigations was an examination of the connection between the type of defect, the likelihood that it would be found through current track inspection techniques, and the probability that the defect would result in a derailment.

That the likelihood of a derailment and its associated cost have a significant effect on rail replacement strategies should come as no surprise to anyone. The figure presents a relation for optimum rail replacement time in terms of rail defects per mile per year as a function of derailment cost. Clearly, as the cost of derailment increases, the rail must be removed from track at an earlier point in its life.

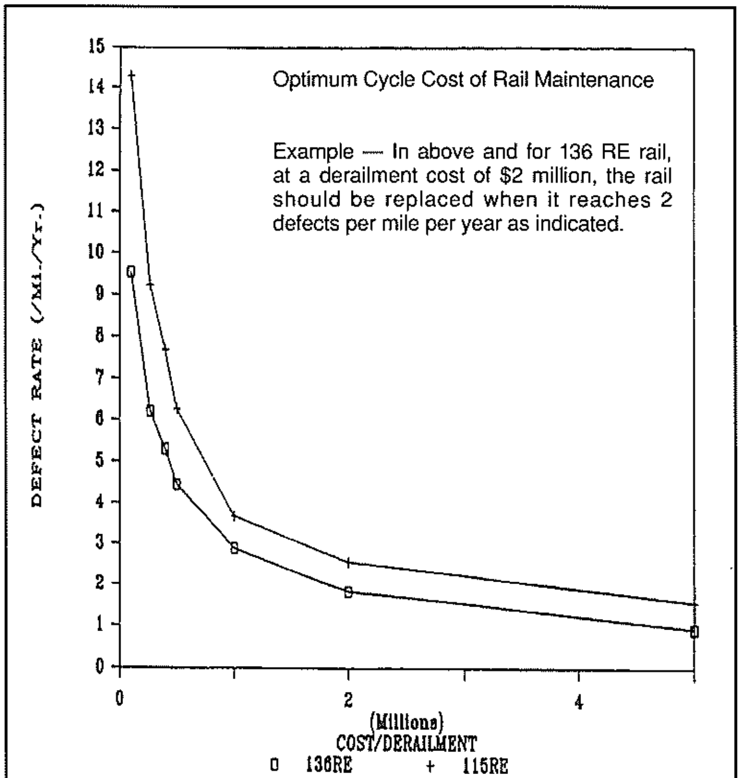

Figure 1 — Effect of derailment cost on rate defect rail at time of removal

Earlier investigations into the probability of rail-caused derailments[2,3] revealed that the occurrence rate for such incidents is approximately one per 100 to 200 service breaks. In addition, the ratio of 'service breaks,' defects that result in a rail service break in track but not necessarily a derailment, to detected defects located by an inspection vehicle is generally in the range of 0.1 to 1.0.

Two classes of failure studied

However, recent research has also indicated that such ratios may vary according to the type of rail defect. For one investigation, analyzing rail-caused derailments during the period between 1980 and 1984, the types of rail defects were divided into the following two classifications based on the stress-causing mechanism:

1. *Flexure stress-dependent failures.* This group included bolt-hole failures, broken rail bases, field and plant weld failures, head and web separations, and piped rail.

2. *Contact/residual stress-dependent failures.* This class included detailed fractures caused by shelling/head checks, as well as by engine-burn fractures, horizontal split heads, transverse/compound fissures, and vertical split heads.

Joint bar failures were not examined because of their relatively small population size and low cost per derailment.

During the period studied, a total of 194,375 rail defects were recorded, during which 255 rail-related derailments occurred. The table presents a summary of this data, including a breakdown of defects according to the two classifications given previously.

Upon analyzing the distribution of defects between these two stress-related groupings, it can be seen that while the distribution of derailments are not that far apart relatively (45 percent to 55 percent), the same cannot be said for the distribution of service failures (64 percent to 36 percent), the detected defects (61 percent to 39 percent), and total defects (61 percent to 39 percent). Even more important are the derailment/defect ratios as described in the table.

The overall ratio of derailments to service defects is 0.005 or 1/200. This corresponds with earlier values.[2-3] However, that portion of defects from contact stress, as shown in the table, accounts for more than twice the derailment service defect ratio than do defects from flexural stress alone. Consequently, for defects related to contact stress, the derailment/service defect ratio is 1/133, while that for flexural stress is 1/286. At the same time, however, the ratios of service to detected defects are not that far apart for the two cases shown in the table (0.364 to 0.329).

Rail defect statistics for selected roads (grouped by failure mode)

	Flex Stress	Contact Stress	Total
Number of Derailments	115	140	255
Number of Service Failures	32,441	18,554	50,995
Number of Detected Defects	86,763	56,362	143,125
Total Number of Defects	119,319	75,056	194,375
Derailments/Service Defects	0.0035	0.0075	0.0050
Service/Detected Defects	0.364	0.329	0.350
Derailments/Total Defects	0.0010	0.0019	0.0013
Service/Total Defects	0.272	0.247	0.262
Detected/Total Defects	0.727	0.751	0.736

With regard to the ratio of derailments to total defects as given in the table, once again the contact-stress related defects have a derailment/defect ratio that is about twice that of the flexural stress-related defects. Thus for contact stress defects, there was one derailment for every 526 defects, while for flexural stress defects it was one in 1000.

It has been duly reported that "contact stress-related failures are causing a disproportionately large share of rail-related derailments and derailment costs."[1] Admittedly, the reasons for this are still not well-known. Still, the observations made that contact stress-related defects will more probably cause a derailment than flexural types can help the track maintenance officer to more effectively plan rail inspection and rail replacement strategies and minimize risks of derailment.

References:

1. Davis, D.D. and Gudiness, T.A. "Rail Planning: A Progress Report of the Track Maintenance Research Committee," Association of American Railroads Report WP-128, October 1987.
2. Davis, D.D.; et al. "The Economic Consequences of Rail Integrity." Third International Heavy Haul Railway Conference: Vancouver, British Columbia, October 1986.
3. Orringer, O. and Bush, M.W. "Applying Modern Fracture Mechanics to Improve the Control of Rail Fatigue Defects in Track." Bulletin 689 of the American Railway Engineering Association, September 1982.