Linking Lubrication and Rail Wear, Fatigue

As greater attention is focused on the benefits of rail lubrication, the relationships between rail wear, lubrication and contact fatigue escalate in importance to maintenance of way personnel responsible for keeping their tracks in safe operating condition. An earlier Tracking R&D (see RT&S January 1985) discussed the emergence of fatigue as the dominant rail replacement criterion in a well lubricated track environment. What follows focuses on several ongoing research activities aimed at quantifying this phenomenon.

Recent research[1] indicates that wear and contact fatigue lives of rail are affected by three distinct sets of parameters. These can be classified as *mechanical* (wheel/rail geometry, wheel/rail stresses, creep forces); *metallurgical* (chemical composition, material properties, grain size, inclusions); and *rheological* (degree of lubrication, properties of the lubricant, roughness of the wheel/rail interface). It is the linkages between these parameters that defines the mechanisms of rail wear and rail surface fatigue.

Lab simulation

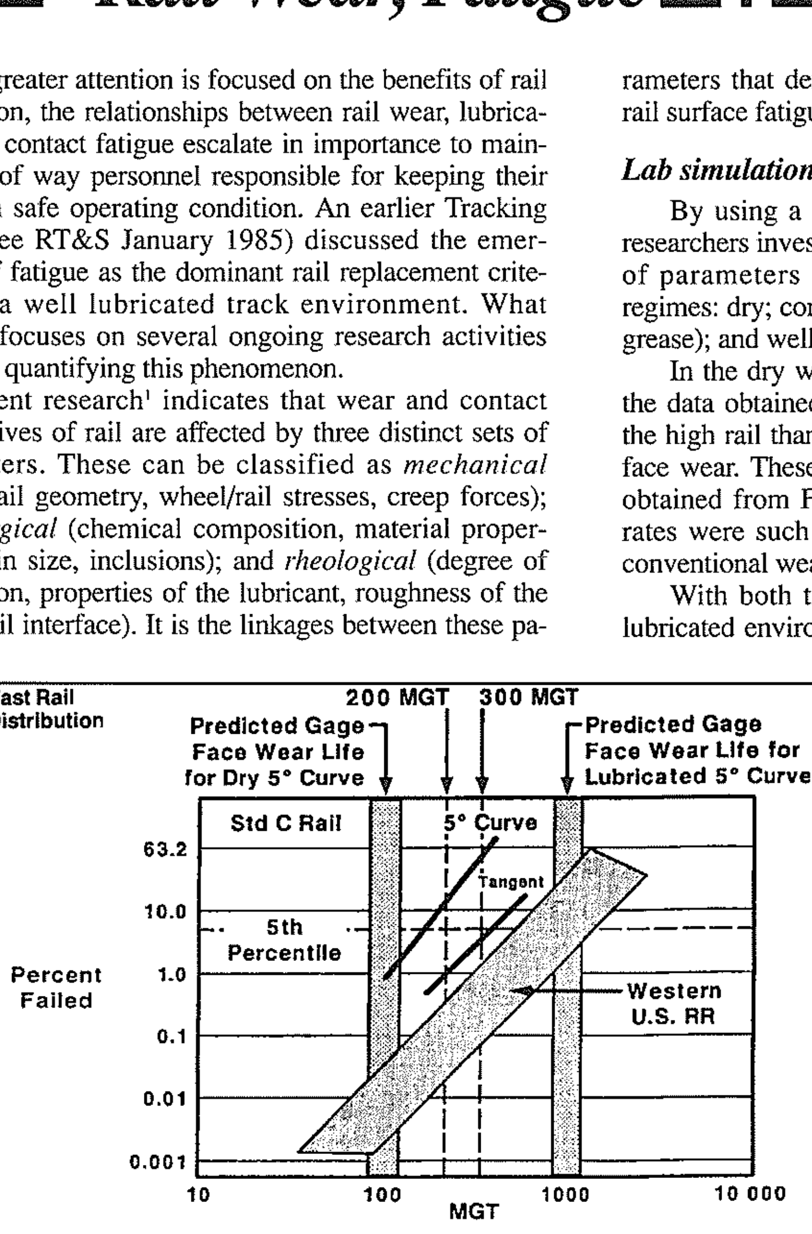
By using a small-scale rail/wheel wear apparatus, researchers investigated the relationship between the sets of parameters noted for three distinct lubrication regimes: dry; contaminated lubrication (sand mixed with grease); and well lubricated (grease only).

In the dry wear environment (no lubricant present), the data obtained revealed significantly higher wear on the high rail than on the low rail, corresponding to gage face wear. These results compare quite well with those obtained from FAST. In both test cases, the rail wear rates were such that the rail would be replaced using conventional wear criterion.

With both the contaminated and uncontaminated lubricated environments, there were order-of-magnitude improvements in wear rates over the dry environment. That is, for the case of sand mixed with grease, the wear rate was reduced by a factor of 10, and under pure grease conditions, the wear rate was reduced by a factor of 100. It should be noted that this reduction in wear rate seems to be unaffected, generally, by the type and quality of the rail steel, similar to the observations reported at FAST.[2]

In both types of lubricated environments, however, the rail began to exhibit surface damage. This occurred in the form of contact fatigue, and well before any wear limit was approached. The damage took the form of cracks in the surface of the rail disc used for the test, though it was not clear whether the cracks began at the surface (spalling) or below the surface (shelling). (For a more detailed description of the

Fig. 1—Fast Rail Failure Distribution



Wear		Fatigue	
Dry	Lub'd	5th Percentile	10th Percentile
80-100	1000+	~180	~200

Figure 1 — Fast rail failure distribution.

difference between these two failure mechanisms, the reader is referred to *Tracking R&D, RT&S,* October 1985.)

The recent data[2] from FAST quantifies further the behavior noted above. The figure shown presents the results of both wear and fatigue behavior at FAST on a 5-degree curve using standard carbon rail. In an unlubricated condition, the rail on this curve would have to be replaced at between 80 and 100 MGT of traffic because of excessive gage-face wear. Under 'fully lubricated' conditions, the rate of wear is reduced to the extent that the rail would require 1000 MGT of traffic before it would reach its side wear limit. This corresponds to the factor of 10 reduction in wear rate mentioned previously.

However, well before this 1000 MGT limit is reached, the rail in the 5-degree curve experienced fatigue defects, mostly detail fractures as shown by the Weibull representation for the 5-degree curve in the figure. Based on this data, the rail reached its 5th percentile level, or when 5 percent of the rails were replaced due to fatigue defects, in approximately 180 MGT of traffic. The actual range was determined to be between 150 and 200 MGT. Thus, 180 MGT is the point at which it is economically desirable to replace the rail due to fatigue (see Tracking R&D of April 1985).

As revealed, the *potential* rail life based on wear was extended from 80-100 MGT to 1000 MGT with the fully lubricated rail environment. Nevertheless, the development of fatigue defects resulted in an actual rail life of only 180 MGT. Consequently, the rail life was extended by only 80 to 100 MGT rather than the full theoretical potential of a possible 900 MGT under a fully lubricated regime. These results suggest that techniques for the control of rail fatigue defects, such as use of fatigue-resistant, clean steel, controlled wear, or profile grinding offer the potential for significant extensions of rail life.

References:

1. Kalousek, J., "Establishment of Quantitative Wear and Fatigue Model for Railway Rail Subjected to Heavy Traffic Conditions and Differing Lubrication Regimes", National Research Council Canada Report TR-WE-42, NRC No.23488, May 1984.
2. Steele, Roger K., "Rail Lubrication: The Relationship Between Wear and Fatigue", Transportation Research Board Railroad Maintenance Workshop, Amherst, MA, 6/85.