

Detection of Rail Steel with Increased Fatigue Potential

The development of fatigue defects in rail remains one of the key factors in determining rail life in track. Recent research has linked fatigue life with the metallurgical cleanliness of rail steel (Tracking R&D, June 1988). This research has shown that the presence of nonmetallic inclusions, particularly oxide inclusions can be related to the incidence of fatigue defects in the rail steel. However, a quantitative relationship between the occurrence of fatigue defects and the size of these inclusions, as measured by standard evaluation methods, was not developed in that research.

But other recent activity did address the issue of inclusion measurement and its relation in the development of fatigue in rail.¹ In order to evaluate the relationship between inclusion type, size and location with the development of fatigue defects, a group of 14 rails containing fatigue damage, including eight fractured in service, were examined. Also studied were 11 new rails without any service experience. Chemical analysis of the rails indicated that composition alone cannot distinguish fatigue damage. Similarly, there was no correlation between rail hardness and fatigue.

Detailed analysis of the origin of fatigue cracks in the 14 damaged rails, however, showed that all of the fatigue cracks originated near the gage corner approximately 0.70 in. (17 mm) below the top of the railhead and 0.50 in. (13 mm) from the gage face. The locations of all 14 crack origins are illustrated in Fig. 1, which superimposes these origin points onto a railhead cross-section. The origins also appear to be confined to a 0.40 in. by 0.40 in. area in the railhead. This location was not affected by the hardness of the rail or by heat treating. (Five of the 14 rails were heat treated.)

Metallurgical analysis of these rails at the zone where the crack origins occurred showed streaks of nonmetallic inclusions for several, but not all, of the fractured rails. This led to the development of a new method

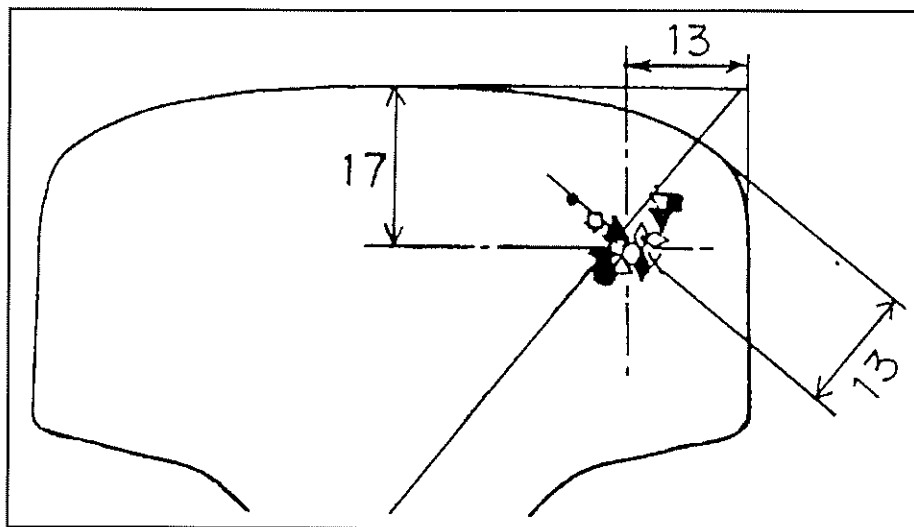


Figure 1 — Distribution of crack origins on cross section of 132RE rail.

of measuring inclusions, in which alumina clusters of 100 micrometers (0.004 in.) in length or greater were measured. The number of such clusters and their total length were then counted and evaluated.

For all 25 rail sections analyzed in this study, Fig. 2 shows a well-defined relationship between the number and total length of the alumina clusters with the fatigue-damaged rails. In fact, based on these results, all 14 fatigue-damaged rails exhibited a total length of alumina clusters greater than 2,000 micrometers (0.080 in.). In contrast, only two of the 11 new rails had inclusion levels greater than 2,000 micrometers, suggesting that 2,000 micrometers could be the limit for alumina clusters permitted in standard steels to minimize the development of fatigue defects.

In head-hardened rails, alumina clusters totaling 5,000 micrometers or more were observed in the fatigue damaged rails, which suggests that a total alumina cluster length of 5,000 micrometers be used as a threshold for harmful inclusion content in head-hardened rail.

Corresponding analysis of these rail samples using American Society of Testing Materials and Japanese Industrial Standards techniques did not show as well-defined a relationship as did the technique of measuring total length of alumina clusters.

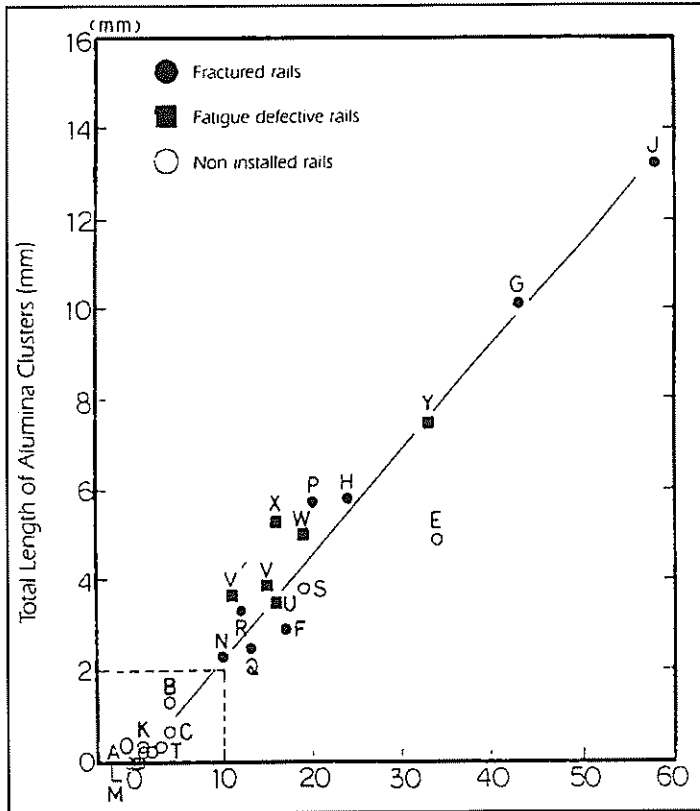


Figure 2 — Total Length of Alumina Clusters (mm).

While further investigation of additional rails is recommended, it appears this new measurement technique offers the potential for developing new rail steel standards of cleanliness that are directly related to the elimination of fatigue defect-producing inclusions. This, in turn, can result in longer life rail steels and more cost-effective rails for heavy axle load main-line service.

Reference:

1. Sugino, K.; Kageyama, H.; and Newell, H.W.: "Detection Method for Harmful Inclusions in Rail Steel"; Bulletin of the American Railway Engineering Association, No. 716, Volume 89, May 1988.