

Crack Growth in Rails

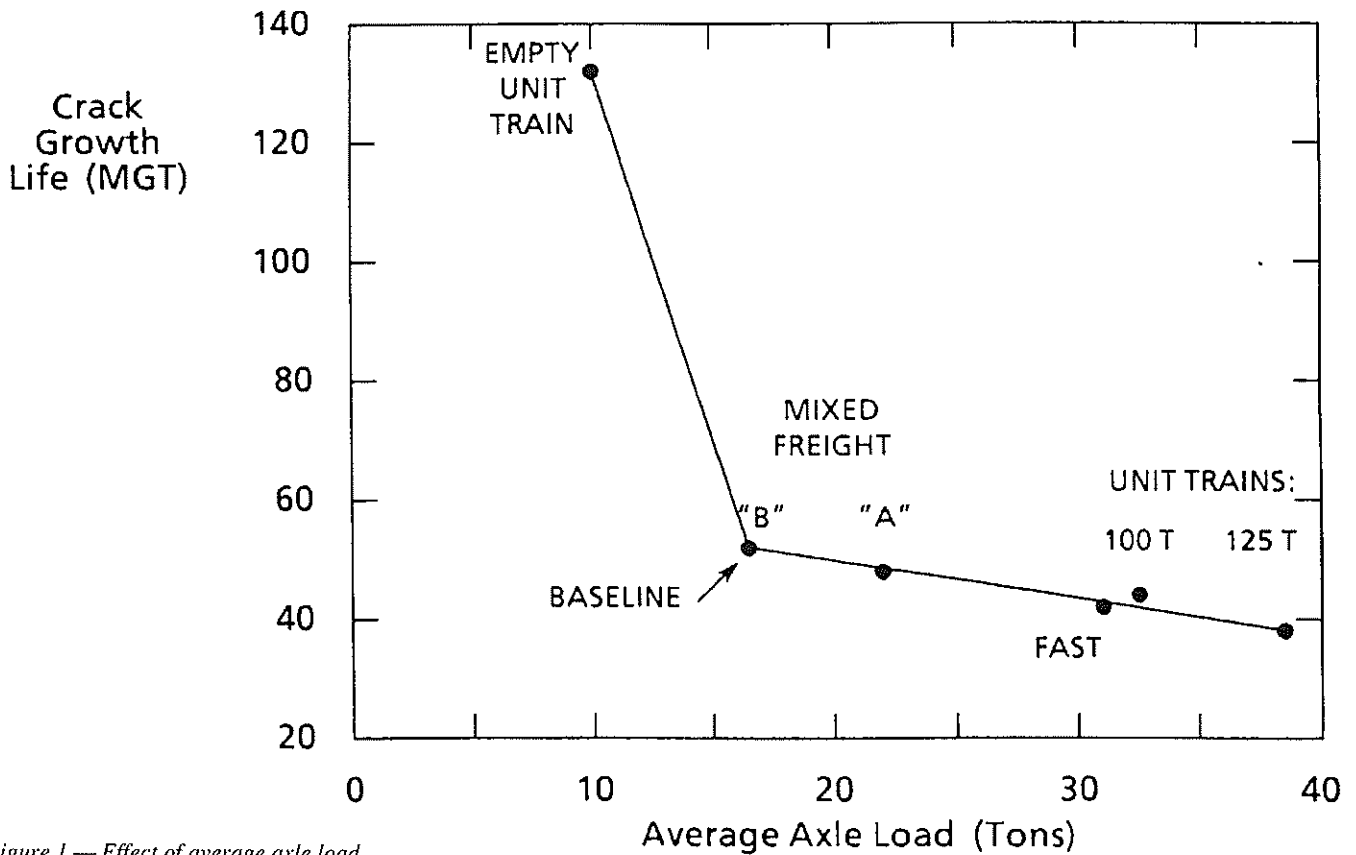


Figure 1 — Effect of average axle load.

The life of rail, in track, can be divided into two stages: defect initiation and defect propagation.

Defect initiation refers to the period of time (or the tonnage passing over the rails) during which a defect develops internally, within the rail, but cannot be detected by existing inspection techniques. Defect propagation refers to the period of time it takes a "detectable" defect to grow to a size that will "fail" under traffic.

Since the former period (initiation) is significantly longer than the latter (propagation), most research into rail life has concentrated on the initiation of defects. However, recent investigations into the optimization of rail inspection strategies, i.e. techniques for effectively scheduling rail flaw inspection, (see *RT&S*, January 1987) has led to an increased interest in this crack growth period.

One area of recent research, directly related to this issue of crack propagation, is that of estimating the "safe crack growth life" of rail under traffic.¹ This safe crack growth life has been defined as the tonnage required to grow a defect (and in particular a detail fracture) from a size that is barely detectable to a size that will cause the rail to fail under the next train.¹ This interval can then be used to establish a maximum rail test interval and thus allow for a more efficient scheduling of rail testing.

Using sophisticated computer modeling techniques, combined with experimental data, the sensitivity of this crack growth period was examined for "detail fracture" types of defects. A lower detection limit for the defects of 10 percent of the head area was used. This corresponds to the other recent studies on the detection reliability of rail test equipment.² Rail "failure" was taken to occur when the defect reached 80 percent of head area.

Key parameters

This sensitivity study indicated that the period of crack growth is sensitive to several key track, traffic and environmental parameters. These include: temperature below the 'neutral' temperature of CWR, axle load, wheel/rail contact point, track modulus, residual stress in the railhead, rail size and track curvature.

The effect of axle load on this crack growth "life" is illustrated in Fig. 1. While increased axle loads result in a reduction in crack growth life, empty cars appear to cause significantly less damage than loaded freight vehicles. In fact, running of returning empty unit trains on the same track as the loaded unit trains reduces the number of loaded trains the rail can carry by less than 10 percent.¹

Fig. 2 presents the effect of increased lateral loads, associated with increasing curvatures. As can be seen in this figure, crack growth life is strongly affected by increasing curvature, up until 6 degrees of curvature.

The relationship between crack growth life and rail bending is illustrated in Fig. 3 which shows the effect of rail section size (and corresponding moment of inertia) on crack propagation. A similar behavior is noted for the effect of track stiffness, or modulus, thus indicating that rail bending does have a significant effect on the growth of detail fracture defects. Similar behavior was observed for the other mentioned parameters.

Using this type of analysis, it is possible to develop safe inspection intervals, to minimize the possibility that a defect will escape detection, because of inspection

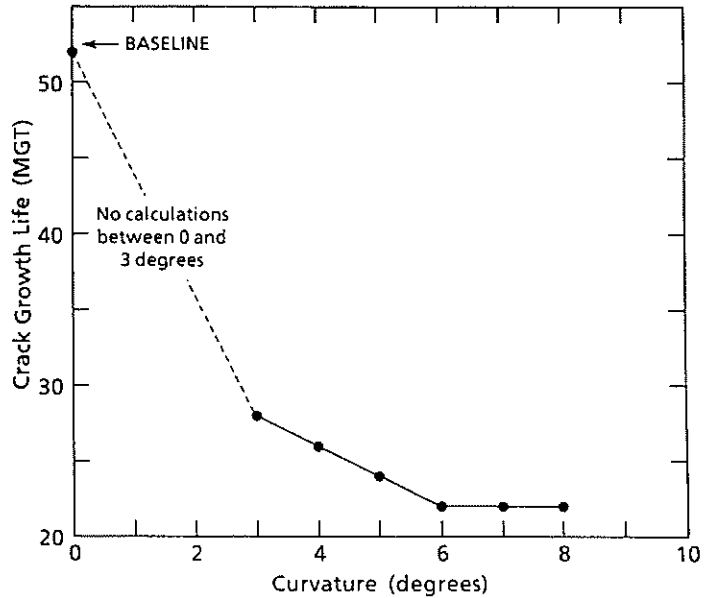


Figure 2—Effect of track curvature.

equipment reliability or sensitivity. This in turn will allow for more efficient scheduling of rail testing, while minimizing the risks of rail-caused derailment.

References

1. Orringer, O. et al, "Crack Propagation Life of Detail Fractures in Rail," Department of Transportation Report DOT/FRA/ ORD-88/13, October 1988.
2. Roney, M.D. "Rail Flaw Detection — Where Is It Heading," AREA Committee 2 Symposium on Automated Track Measurement, Chicago, IL, March 1988.

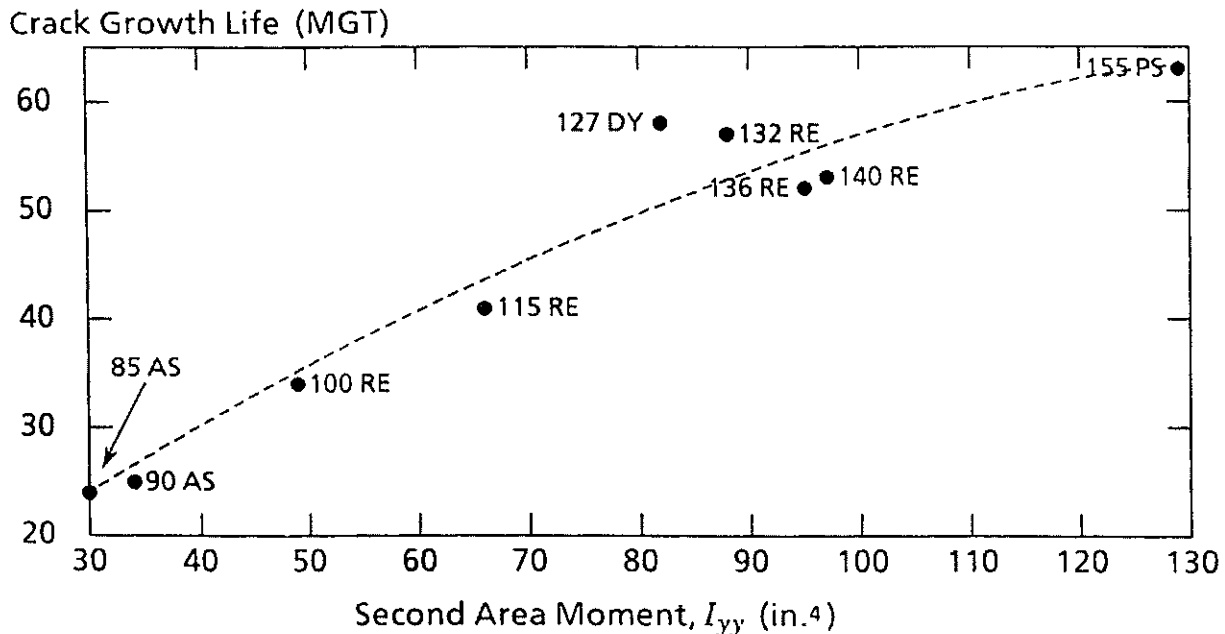


Figure 3—Crack growth life versus rail vertical bending stiffness.