Predicting Rail Defects

The ability to predict rail fatigue life, and more specifically, the occurrence of rail fatigue defects, is the goal of several active research programs. An earlier *Tracking R&D* (see RT&S, April '85) has already addressed one such approach. Another approach was based on the statistical analysis of large quantities of rail defect data. It has resulted in several interesting observations with respect to defect occurrence and prediction.

One recent attempt to analyze rail defect data statistically was carried out under the sponsorship of the Federal Railroad Administration.[1] This study used information from almost 8000 miles of a major railroad's track. The data included over 21,000 rail defects occurring during a 2 1/2 year period. Data was also obtained from over 2700 miles belonging to another large railroad and involved 7400 defects which had formed during a five-year period. The defects analyzed consisted of both *bolt-hole breaks and detail fractures.*

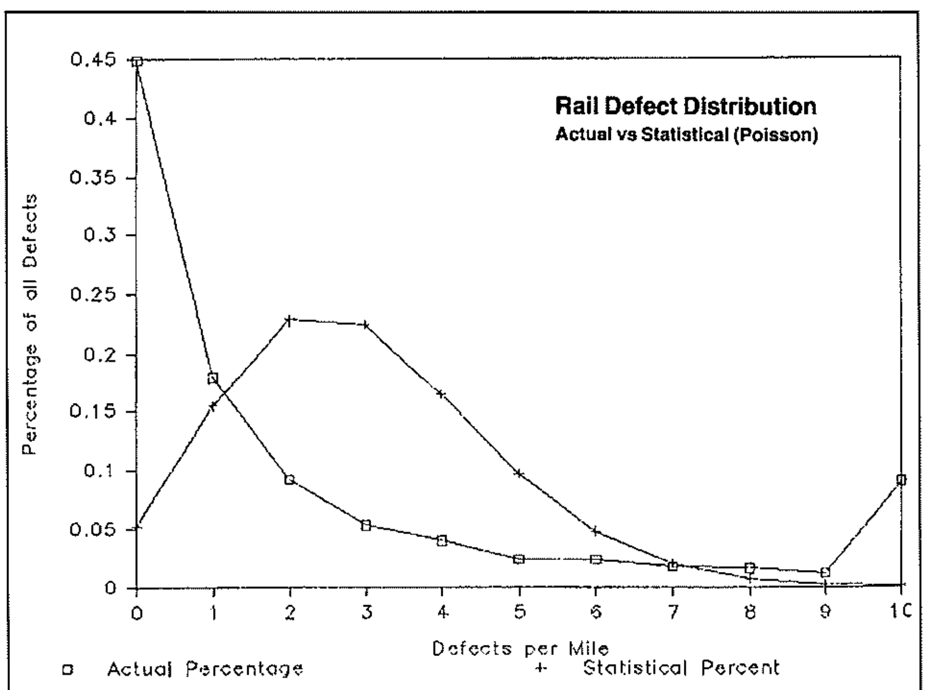

Figure 1 — Rail Defect Distribution

History a predictor

Consistently, the analysis revealed past defect history to be an important predictor of future rail defects. In fact, in all but one analysis, investigations of both classes of defects mentioned above disclosed that the best single predictor of the likelihood of future rail defects for a given section of track (in this case, one-mile sections) was the track mile's past record of rail defects. For the one exception noted, past history showed up as the second best predictor.

Statistical analysis further indicated that data from the most recent years showed particularly high correlations thus providing valuable insight into future defect occurrence.

In addition, related analysis demonstrated that a "strong position relation exists" for neighboring segments (miles) of track. That is, there appear to be segments of track — probably with certain common traffic and track characteristics — which tend to support a clustering of rail defects.

In fact, the analysis of data in this study illustrates a distinct tendency for rail defects to cluster on certain segments of track, and to recur yearly on the same stretches. While certain of the characteristics found in these segments may be identified, for example cumulative tonnage and rail age, the analytical method does not necessarily lend itself to specifically identifying these conditions. Rather, an engineering type of analysis may have to be used for further characteristic definition. However, the clustering of defects on the same sections of track, and which recurs from year to year, appears to hold for both the major defect classes examined, even though they have failure mechanisms that are different.

An additional set of evidence supporting this conclusion is shown in the given figure. It plots the actual percentage distribution of defects for over 6000 miles of existing track against a statistical (Poisson) distribution, which assumed that the defects occurred purely at random. As can be clearly seen in the figure, the two curves differ significantly. Furthermore, at the high defect-per-mile categories, the actual defect occurrence was significantly higher than the random case. These high defect occurrence segments are actually the clusters.

Based on this study, it appears that the historical pattern of defect occurrence along the track would make an effective predictor for the future defect locations. In fact, a major freight railroad recently tried out this concept. It first proceeded to analyze the distribution of defects along its track, using the previous year's reported rail defects both detected and service. After plotting these defects onto a track profile, it found that defects did in fact tend to cluster around certain track segments. These were defined as those stretches of track which had at least one mile with 3 defects/mile/year, and the adjacent miles (including one mile on either end) with no defects. These segments, in turn, often corresponded to distinct track features that represent severe service environments.

Adjusting inspection schedule

The railroad consequently modified the inspection schedule of its rail defect detector car(s). It reduced the number of annual inspections (in some cases from 3 to 2) in those segments where the defects did not cluster, and maintained, or increased as appropriate, the inspection car frequency in those areas where clusters appeared. The results to date seem to indicate that the railroad continues to find the same number of defects that it has in the past, but now at reduced inspection costs. If this trend continues, it would appear that the rescheduling of detector cars based on this clustering of rail defects may prove to be an economical technique for monitoring rail.

1. Mack G. A., Hopper A. T., Meacham, H. C., "Analysis of Rail Defect Data from Burlington Northern Railroad and Atchison, Topeka, and Santa Fe Railroad," Report DOT/FRA/ORD-84-06, July 1984.