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Heavy Axle Load Revenue Service Rail Performance—Tehachapi, CA

SUMMARY

The Transportation Technology Center, Inc. (TTCI) in Pueblo, CO, performed rail performance tests in revenue track in cooperation with Union Pacific Railroad (UP). Figure 1 shows an in-revenue rail performance test at Site 3, Milepost (MP) 340 at Tehachapi, CA. These tests suggest that new versions of premium rails have an average expected life of 200 million gross tons (MGT), based on a 0.75-inch gage face wear limit, or approximately 900 MGT life using a 30 percent head area loss criteria.

For 2 curves where exact MGT was known, expected rail life using a 0.75-inch gage wear limit ranged from 232 to 245 MGT. The environment included severe mountain grade and curvatures of 6 to 10 degrees. In the 169 MGT of the monitoring period, there was less than a 10 percent variation in predicted rail life between the rails evaluated. During this same period, no rail grinding was performed, and no rail surface deterioration was noted.

Similar rails tested at the Facility for Accelerated Service Testing (FAST) had approximately double the expected life, suggesting that train and lubrication conditions in the field were different and more severe. No strong correlation between rail hardness and ranking of wear rates was observed.

Figure 1. In-Revenue Rail Performance Test, Site 3, MP 340 at Tehachapi, CA

BACKGROUND

Rail is one of the most valuable assets in a railroad's inventory of track components. In the past 5 years, railroads have annually purchased nearly 500,000 tons of replacement rail at an approximate total cost of $1.25 billion. While laboratory tests and performance evaluations conducted at FAST provide valuable comparative information, they do not simulate all variables that rail must survive in revenue service.

Rail manufacturers are continually improving materials; thus the industry needs updated information on rail performance to determine optimum products for a given situation. Rail performance can be monitored by a number of parameters. Wear and fatigue, however, are the two most important issues related to total rail life.

Recently the FAST program conducted an extensive evaluation of state-of-the-art rails, reported in the Technology Digest 04-010. FAST results, after over 300 MGT of service, indicated no surface rolling contact fatigue (RCF) on any test rails. Some failures, however, originated at the rail base.

In this test, two rail types exhibited RCF after 350 to 400 MGT. FAST results are obtained with a fully conformal rail/wheel contact pattern. For this reason, revenue service performance monitoring is an essential adjunct to laboratory tests and in track evaluations at FAST.

FIELD TEST LOCATION AND LAYOUT

In cooperation with UP, a rail test site was made available in the Tehachapi Pass area of California. Figure 2 shows the general site, which is located in a severe mountain territory with 2 percent grades and curves of 5 to 10 degrees. As referenced earlier, Figure 1 shows Site 3, MP 340. Traffic is mixed freight with a high percentage of intermodal equipment. Within the test zone, five test curves were selected for installation of premium test rails, as shown in Table 1. The last column shows average predicted life for all rails based on a 0.75-inch gage face wear limit.

Table 1. Five Test Curves Projected

Curve	MP	Curvature	Projected 0.75-Inch Gage Life
Site 1	336.0	6.3	245 MGT
Site 2	339.5	10.0	178 MGT*
Site 3	339.9	10.0	215 MGT*
Site 4	340.6	7.21	232 MGT
Site 5	343.2	10.0	147 MGT*

*Projected wear life is based on wear rates calculated from estimated tonnage as these curves were located adjacent to sidings. Curves 1 and 4 were located on single track sections with known MGT.

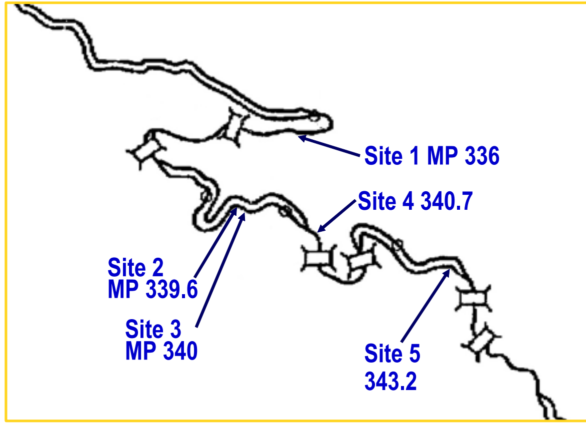

Figure 2. General Site Location

Rails tested in this field evaluation included a range of state-of-the-art premium materials available in North America. All rails were 141 RE rail. The premium pearlitic rail types in the test included:

- Corus America, Inc.: Low-alloy, head-hardened rail
- Nippon Steel Corporation (NSC): High-carbon, hypereutectoid HE 400 rail
- NSC: High-carbon, hypereutectoid HE X1 experimental rail
- NSC: High-carbon, hypereutectoid HE X3 experimental rail
- JFE Steel America, Inc. (formerly NKK Corporation): Super Pearlitic rail
- International Steel Group, Inc. or ISG (formerly Pennsylvania Steel Technologies, Inc.): Low-alloy, high-carbon rail
- Rocky Mountain Steel Mills: 1-percent carbon pearlitic (OCP) rail
- Voest-Alpine Schienen GmbH and Company KG: Low-alloy, high-carbon rail type UHC-HSH

While the FAST loop generally provides steady state test conditions, in the field, items such as lubrication and train speeds can vary from curve to curve, as well as within a curve. UP selected the NSC HE 400 rail type as a control rail to be installed at various locations through each test curve. This allows wear rates to be determined on the same rail at all locations within a curve, thus capturing variables that might influence wear or fatigue at one end or the other of a particular curve. Figure 3 shows the layout of rails in Test Curve 1, which is typical of all test curves.

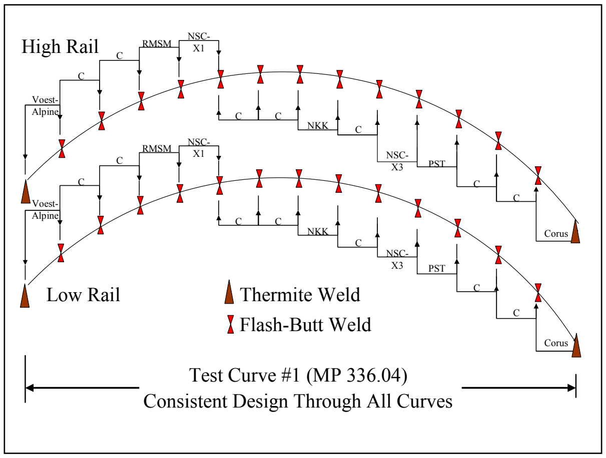

Figure 3. Rail Evaluation Test Layout Shown for Curve 1

Rail Measurements and Inspections

Once installed, the rail was marked to allow repeated measurements at exact locations. Rail wear was measured using a rail Miniprof™ profilometer at each end of every test rail and the adjoining control rail. Data analysis included determining area (mm2) loss, as well as W1 (head height loss), W2 (gage face loss), and W3 (gage corner loss) parameters. To compensate and allow for small variations in initial profile and other variables in reaching a conformal profile, performance is based on data obtained after the initial 40 MGT of traffic.

Other measurements included rail hardness (collected using a portable Eqotip device) and rail surface inspections. During each visit, a detailed examination of rail surface conditions was conducted for the entire rail length. These inspections were conducted every 30 to 40 MGT until approximately 169 MGT of traffic had been applied. Sites 2, 3, and 5 are located on the mainline portion of track with sidings; therefore, less tonnage is accumulated on these curves than the other two sites. For purposes of computing wear rates, most of these curves were estimated to receive 20 percent less than the nearby single track sections. As actual tonnage for the sidings was not available, the true MGT may vary from these estimates.

Wear Results

Rail profile measurements are plotted against tonnage to allow calculation of wear rates. This allows comparisons to be made with other rails in the same test curve and by use of the control rails to determine in-curve variations, as well as compare other test curves.

Figures 4 and 5 summarize area loss wear rates for each rail type, averaged for all test curves, for the initial 169 MGT. Longer term tests conducted at FAST show a gradual decrease in wear rate (for all test rails) after about 150 MGT of traffic. Predicted rail life may be longer than that shown in this report, based on the first 169 MGT.

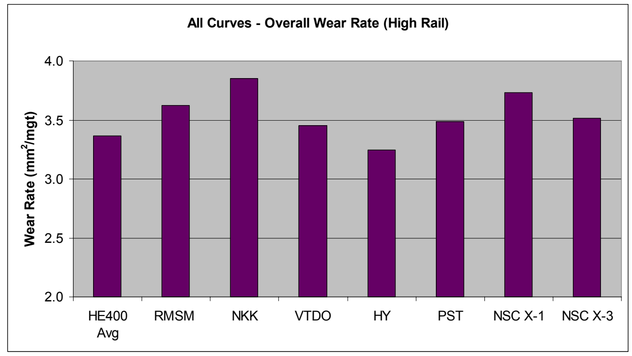

Figure 4. Total High Rail Wear Rate (area loss in mm^2/MGT) for Complete Test Period

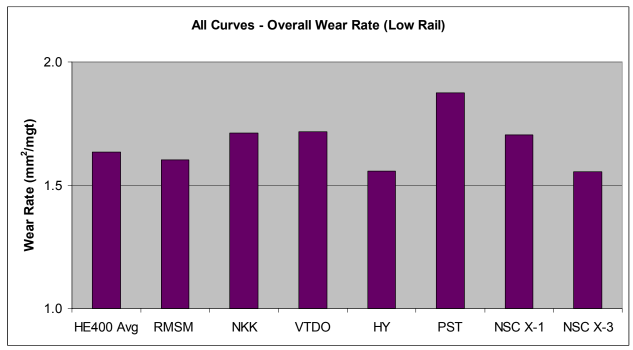

Figure 5. Total Low Rail Wear Rate (area loss in mm^2/MGT) for Complete Test Period

A common measurement to determine rail replacement in high curvature territories is gage face wear. In the Tehachapi Pass area, which is equipped with concrete ties, re-gaging is not an option. The end of rail life is often reached when side wear reaches 0.75 inch. This allows for some additional gage widening due to fastener deflection, rail seat abrasion, and pad deterioration. Figure 6 shows gage face wear rates for test rails. The relative ranking between rails is similar to that shown from high rail area loss (Figure 4). The average projected 0.75-inch gage wear life of all curves of the highest to lowest wearing rail is between 185 to 210 MGT. For the existing operations and lubrication conditions at this site, projected rail life (80 MGT/year) would range from 2.3 to 2.6 years.

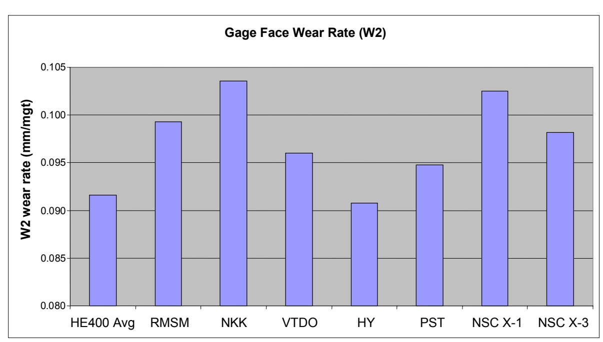

Figure 6. Gage Face Wear Rate (MiniProf W2) in mm/MGT, for the Complete Test Period

Another method used by some railroads calls for rail replacement when 30 percent of the head area is worn. Using the 30 percent criteria, the lowest projected life is 900 MGT, well above the side wear limit. This suggests that improved rail lubrication should be considered if longer rail wear life is to be achieved. These projections assume no metal lost to grinding. Should surface fatigue or profile variations require grinding, rail projected wear life based solely on percent head area loss would be less.

HARDNESS RESULTS

Hardness data obtained near the beginning and end of testing is averaged for all curves and shown in Figure 7. Data suggests that the high rail hardness increased for most rails with applied tonnage, while the low rail exhibited less change or a slight increase over the same period. No direct correlation with hardness and observed wear rate exists.

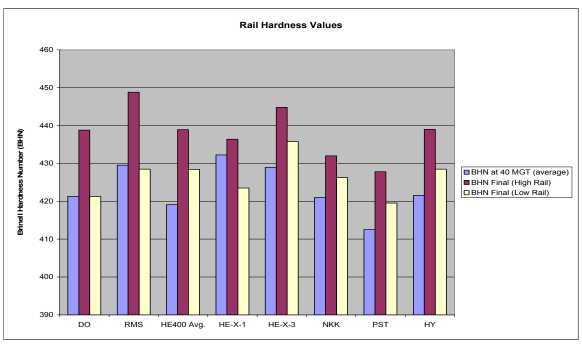

Figure 7. Hardness for All Test Rails as Installed for All Rails and High and Low Rails at End of Test

RAIL SURFACE PERFORMANCE

One item that could reduce projected rail life would be deterioration of the running surface, leading to spalling or chipping. In many cases, this requires the use of grinding to eliminate these defects. In the 169 MGT of this test, no significant rail surface deterioration was noted. Figure 8 is an example of typical rail surface conditions observed after 160 MGT of traffic. If grinding were limited to the top rail areas, then gage face life, which is the limiting factor at the test site, would not be significantly reduced.

Figure 8. Photo of Rail Surface Condition After 169 MGT

CONCLUSIONS/FUTURE WORK

- Using a 0.75-inch limit for gage face wear, rail life of all rails in the 5 test curves is predicted to 210 MGT with the present lubrication policies.
- Thirty percent head loss limit projects rail life of 900+ MGT if gage face wear can be reduced.
- No rail grinding was conducted during this period, and no adverse rail surface conditions were noted.
- Rail life projections do not consider grinding or the development of rail surface fatigue.

An ongoing Top of Rail friction control test in this area will be monitoring rail wear under improved gage face lubrication to address the total rail life issue.

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