TECHNICAL NOTE

TRANSPORTATION TEST CENTER
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DEFECT AND WEAR STUDIES ON PREMIUM AND STANDARD RAILS RAIL WEAR EXPERIMENT RME IV, 0-35 MGT

by
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ABSTRACT

This report presents the first results of the Rail Metallurgy IV Defect and Wear Studies at the Facility for Accelerated Service Testing (FAST). The installation and design of the test are described, along with data results from the first 35 million gross tons (MGT) of traffic over the test section. The primary objective of testing is to evaluate wear differences between premium rails.

BACKGROUND

The previous Rail Metallurgy Experiment (RME III) at FAST was operated from 1979 to 1983 for a total tonnage of over 300 MGT. The first 200 MGT consisted of four blocks of 50 MGT each wherein approximately 40 MGT were run lubricated followed by 10 MGT of dry operation each period. Findings of the first 200 MGT of dry and lubricated operations were reported at the RME III portion of the 1981 FAST Conference.(1)* The next 107 MGT were operated under fully lubricated conditions.

Data analysis of the first 200 MGT showed that wear rates for the four dry periods were very repeatable. Standard carbon rail exhibited wear rates ranging from .006 to .007 inches per MGT, varying no more than 20%.

In the lubricated periods, however, including the last 107 MGT period, standard rail showed a wide range of wear rates, from .001 inches per MGT to .000064 inches per MGT. This fact made it extremely difficult to compare results, as the wear behavior of the rail varied so much over the life of the experiment. The large differences in wear rates observed during the lubricated periods were determined to be the result of variations in the level of lubrication allowed during those periods. This observation led to the conclusion that the benefits and penalties of lubrication are more important than was previously supposed, and the "FAST Lubrication Study" was undertaken from December 1983 to September 1984. Results of this study can be obtained through the TTC Technical Documentation Section.

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*References follow text.

The next rail experiment, funded by the FRA as the "Defect and Wear Studies on Premium and Standard Rails" (RME IV), elected to avoid the problems of interpreting wear results under unknown lubrication by operating only under a dry rail scenario. Although operation in the dry mode will probably limit rail life of standard carbon rail to less than 50 MGT, this rapid wear rate is desirable in providing timely wear results to the industry. Fatigue data will be limited to longer lasting premium rails, whose life under dry conditions is likely to reach about 100 MGT.

To permit the simultaneous operation of both the lubrication study and dry rail wear, the RME IV experiment was installed in Section 07 at FAST in February 1984 (Figure 1). All subsequent lubrication tests were made only on the outside rail of FAST, leaving dry rail on the inside of the loop--the high rail on the section 07 curve.

DATA

Data for this interim report is limited to allow for a brief preview of results. It consists of high rail gage face wear at 5/8" below the running surface (GP); head height loss of high and low rails, measured separately (HL); rail surface hardness (Shore); and rail hardness using the King Brinell tester.

Other data is also being taken and will be presented in the next interim report after a total of at least 70 MGT of traffic have been applied. Significant differences between the various premium rails could not be accurately determined after only 35 MGT. The additional measurements include low rail metal flow, longitudinal rail surface profile (a measure of welded rail end batter at selected shop welds), transverse rail profiles (RP) for rail shape changes, and laboratory analysis of selected shop weld samples.

TESTING, 0-35 MGT

Test Layout

All test rail in the RME IV section was donated by rail manufacturers to the FRA/TTC.

Figure 2 shows the metallurgy layout as installed in February 1983. At 35 MGT, the standard carbon BHN 248 rail (ties 465 to 567, approximate), showed over 1/3 inch of gage face wear. This rail was replaced by a 4 rail segment of standard rail (BHN 302) from two manufacturers. The original standard rail was identical to that used in RME III tests.

FAST Section 07 consists of a 5° curve, with 4 inches of superelevation on a -0.05% grade. Train direction for the entire 35 MGT period at FAST was counterclockwise. Train speed was very uniform at 44-45 mph. Almost all trains consisted of four 4-axle locomotives and 70-75 loaded 100-ton hopper cars. A few empty/underweight cars have been periodically placed in the consist. Track is constructed with wood ties using conventional cut spikes/tie plates on slag ballast.

All connections between unlike metallurgies were made with epoxy bonded, huck bolted joints. Virtually no track maintenance was performed during the 35 MGT period.

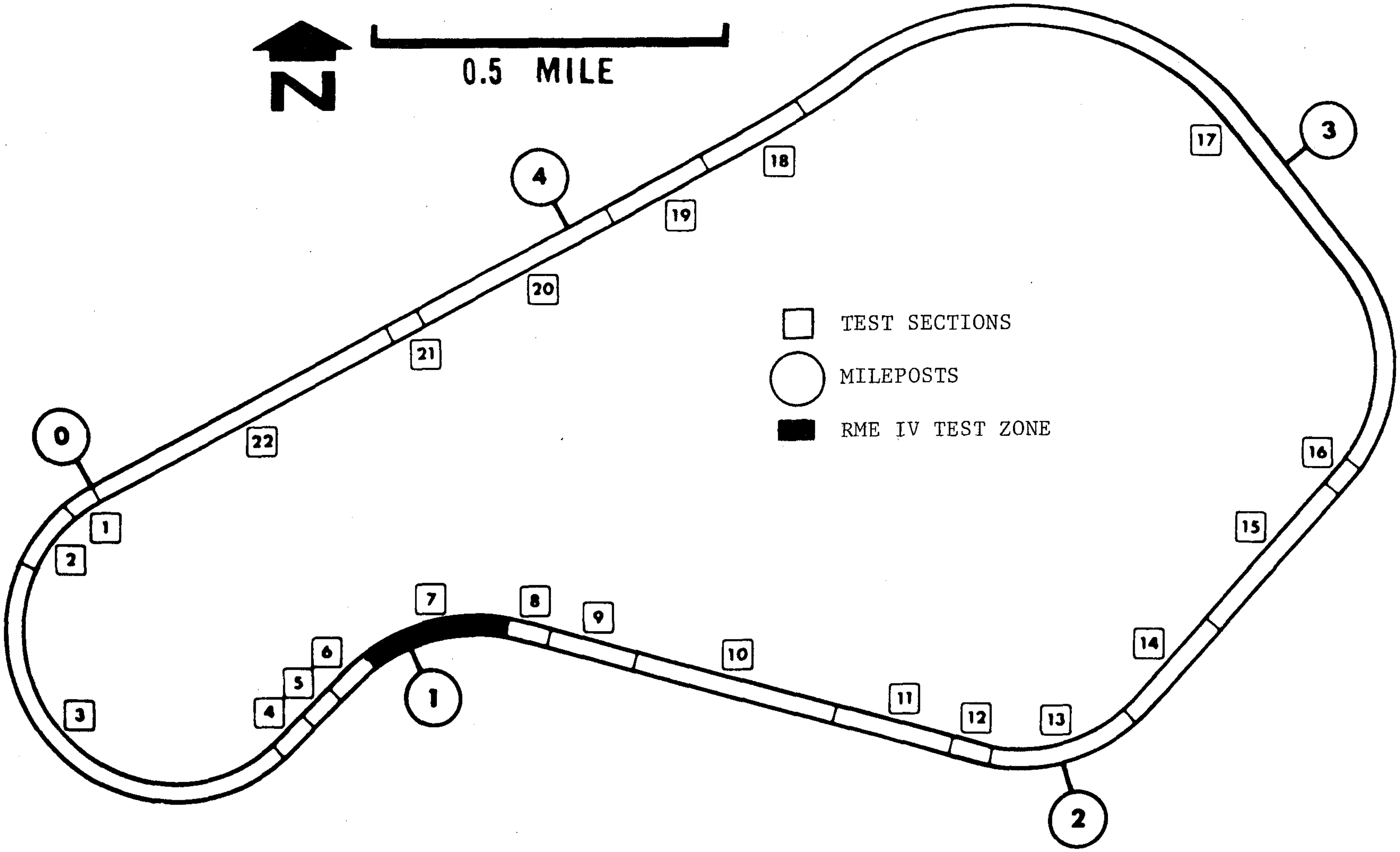

FIGURE 1. THE FAST TRACK SHOWING RME IV.

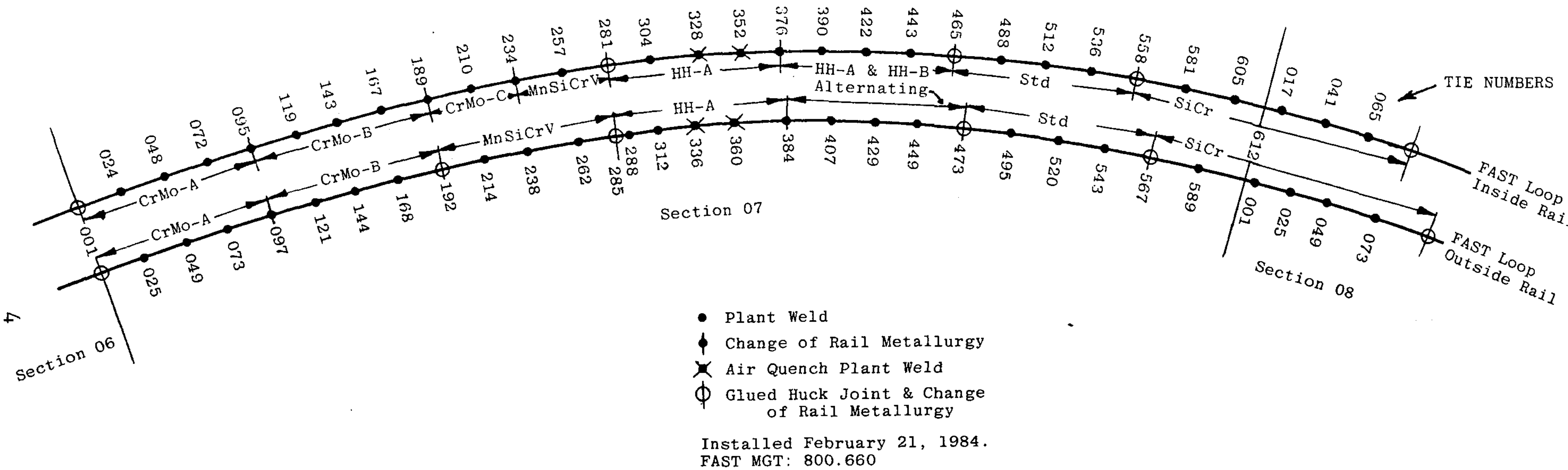

FIGURE 2. SECTION 07 RAIL METALLURGY LAYOUT.

Wear Results

Tables 1, 2, and 3 summarize the wear rates observed for high rail gage face wear at 5/8" below the running surface, high rail head height loss, and low rail height loss, respectively. Figure of merit values compare the wear rates of all rails to that of standard carbon rail. The figure of merit number can be used to estimate how much more rail life could be expected from use of premium rail over standard carbon rail. These values are good under dry rail conditions only. For example, in Table 1, a figure of merit (FM) of 1.8 for CrMo-C rail indicates an expected gage face wear life of 180% that of standard carbon rail (FM 1.0). Lubricated rail conditions create wear rates that tend to be very similar for all metallurgies with FM numbers typically 1.1 to 1.2.

The data for high rail head height loss of HH type A and SiCr-HH is somewhat questionable. The difference in initial profiles could have affected the way initial head wear was measured using the TTC's dial indicator gages. This data should be used with caution until an additional 15-20 MGT of wear are measured to allow a more conclusive wear pattern to emerge.

The low rail wear rates for all metallurgies appear to be acceptable, as are the gage face wear rates. Wear rates were determined by linear regression techniques using the SPSS (statistical) plot package. Data for gage face or head height dimensions is plotted with respect to MGT which allows determination of wear rates.

Hardness Data

Hardness data will be presented in detail in the 70 MGT report. Table 4 summarizes King Brinell data for the test rails.

FUTURE REPORT

This report has been intentionally brief in order to expedite distribution of initial results to the railroad industry. The next interim report, after 70 MGT of exposure, will provide information from all measurements being taken on the rail in test.

In addition to the Section 07 rail, some standard carbon BHN 248 and standard carbon BHN 302 rail were already in place from RME III in Section 03. This rail is either identical to or very similar to that in the RME IV Section 07 test. The lubrication experiment precluded taking any valid dry wear data at these sites; however, FAST will be entering a 20 MGT dry operation phase starting January 1985. During this period, wear data will be obtained at these rails in Section 03, along with the normal data in Section 07.

Results from this operation will aid in correlating past RME III results with current RME III data, and will help determine the effect (if any) of differences in rail wear at back-to-back reverse curves.

It is anticipated that data for the next report will be available by late 1985.

TABLE 1. GAGE FACE WEAR, HIGH RAIL, 0 - 35 MGT.

TIE RANGE	METALLURGY	WEAR RATE (IN/MGT)	FIGURE OF MERIT
465-558	Standard Carbon 248	.00888	1.0
001-095	CrMo A	.00440	2.0
095-189	CrMo B	.00499	1.7
189-234	CrMo C	.00477	1.8
234-281	MnSiCrV	.00681	1.3
281-376	HH A	.00305	2.9
376-422	HH B-clean	.00399	2.2
422-465	HH C-regular	.00397	2.2
558-612	HH-SiCr	.00277	3.2

TABLE 2. HEAD HEIGHT LOSS, HIGH RAIL, 0 - 35 MGT.

TIE RANGE	METALLURGY	WEAR RATE (IN/MGT)	FIGURE OF MERIT
465-558	Standard Carbon 248	.00218	1.0
001-095	CrMo A	.00034	6.4
095-189	CrMo B	.00066	3.3
189-234	CrMo C	.00074	2.9
234-281	MnSiCrV	.00113	1.9
281-376	HH A	.00016	13.6
376-422	HH B-clean	.00063	3.4
422-465	HH C-regular	.00056	3.8
558-612	HH-SiCr	.00013	16.7

TABLE 3. HEAD HEIGHT LOSS, LOW RAIL, 0 - 35 MGT.

TIE RANGE	METALLURGY	WEAR RATE (IN/MGT)	FIGURE OF MERIT
465-558	Standard Carbon 248	.00183	1.0
1-49	CrMo A 136#	.00053	3.4
49-97	CrMo A 132#	.00067	2.7
097-192	CrMo B	.00072	2.5
192-285	MnSiCrV	.00083	2.2
285-384	HH A	.00035	5.2
384-429	HH B-clean	.00075	2.4
429-475	HH C-regular	.00078	2.3
567-612	HH-SiCr	.00039	4.6

TABLE 4. BRINELL HARDNESS (TOP OF RAIL ONLY).

RAIL TYPE	INITIAL	AFTER 35 MGT (high rail)	AFTER 35 MGT (low rail)
CrMo A	288	352	352
CrMo B	294	338	329
CrMo C	302	352	---
MnSiCrV	301	352	352
HH A	330	352	373
HH B-clean	311	352	371
HH C-regular	307	356	350
Standard Carbon	248	326	326
HH-SiCr	364	389	412

RAIL FATIGUE

One of the objectives of RME IV is to monitor the occurrence of rail defects. As of 35 MGT, no rail defects have been detected in the RME IV test limits. This is of no great surprise, as few, if any, defects are to be expected this early in the life of the rail.

Internal inspections for rail flaws are made every 3 MGT using the TTC ultrasonic rail flaw vehicle. Should a flaw be detected, it is verified by hand probe inspection and monitored frequently (generally every other day) until a size of greater than 10% is reached. At that time, the flaw will have angle bars attached for safety and will be removed if it exceeds 30% or breaks under traffic.

FAST Facility for Accelerated Service Testing — TECHNICAL NOTE

The Facility for Accelerated Service Testing (FAST) is located at the Transportation Test Center (TTC), Pueblo, Colorado. It is operated by the Association of American Railroads (AAR) in cooperation with the Federal Railroad Administration (FRA) and the railroad companies and supply industry to conduct accelerated testing of track and mechanical components and systems.

The FAST Program is controlled by a policy committee composed of representatives from FRA, AAR, and the railroad industry. Its policies are implemented through the FAST organization at the TTC. The AAR FAST Technical Manager is responsible for the overall design of the experiments to be conducted at FAST, and the FAST Operations Manager implements the approved experiments in the field in cooperation with the AAR experiment supervisors.

The FAST Track is a specially constructed 4.8-mi* loop divided into 22 sections where specified combinations of track components and structures are installed for testing. It contains 2.2 mi of tangent, 0.4 mi of 3° curve, 0.3 mi of 4° curve, and 1.1 mi of 5° curve; the remaining 0.8 mi is in transitional spirals.

Mechanical components are tested in the FAST consist, which is made up of 4-axle locomotives normally hauling a 75-car, 9,500-ton train. Cars are available from a pool of about 90 cars assigned to FAST. The majority are 100-ton hopper or gondola cars, and the remainder are 100-ton capacity tank cars and laden trailer-on-flat-cars.

A "test run" begins in the afternoon, continues all night, and ends the next morning (five days a week). Each run makes approximately 120 laps of the FAST loop and produces approximately 1 million gross tons (MGT) on the track and about 600 mi on the cars, an accelerated service of about 10 times normal revenue operations in any given period of time.

To ensure uniform wear potential on track and mechanical components, direction of running is reversed each day; the whole consist is turned end-for-end every two days. Blocks of cars are shifted systematically within the consist on a 22-day cycle.

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*Metric Conversions:

1 mi = 1.6094 km
1 ton = 0.907 Mg
1 MGT = 0.907 MGMg

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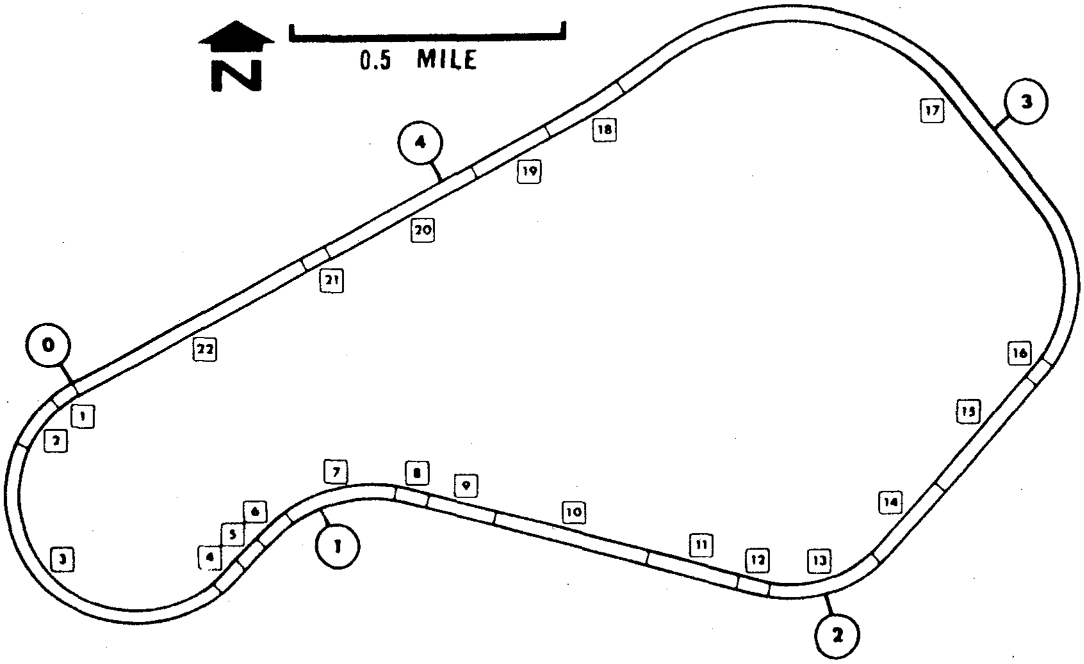

THE FAST TRACK