Report from FAST—Recent Test Experiences

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Recent results from accelerated rail testing performed at the Transportation Test Center are reviewed. This includes rail wear and rail fatigue experiments. Results are from full-scale field tests performed at the Facility for Accelerated Service Testing (FAST). These data represent performance under fully loaded hopper cars of 130 tons each load on the rail. Wear information for standard, alloy, and head-hardened rails under dry conditions is presented. The data allow curve wear life comparisons to be made for rails with differing chemistry and manufactured by different processes. Rail life was extended by reduction of wear through the use of lubrication to evaluate fatigue resistance. In this evaluation program, different lubrication levels were maintained to demonstrate the effect of various wear rates on defect occurrence and growth. Eliminating rail wear increased the defect rate significantly. Rail of higher hardness, in the range of 300 BHN and higher, offered an improvement over softer rails in fatigue resistance.

The Facility for Accelerated Service Testing (FAST) is located at the Transportation Test Center (TTC) near Pueblo, Colorado. The FAST program generates wear and fatigue information on railroad components through the operation of a 9,800-ton train made up of conventional cars and locomotives. The FAST track has been in operation since late 1976, with total applied tonnage to date exceeding 950 million gross tons (MGT). In 1985 the main FAST loop was shortened from 4.78 mi to just over 2.77 mi in an effort to increase the rate of applying tonnage for a given amount of train operation. This increases the MGT application rate in support of track-related tests. The new loop, which incorporates portions of the original FAST loop, is designated the High Tonnage Loop (HTL), as shown in Figure 1.

Rail tests have played a primary role in all FAST/HTL operations. Early tests were aimed at monitoring and reporting basic rail wear information (*1*). To aid in obtaining wear information, the FAST program has developed a number of improved measurement tools that increase the accuracy and efficiency of these tests. As the data base of rail wear information increased, other rail testing programs, including rail profile grinding and fatigue testing, were incorporated into the program (*2*).

Currently, two major rail-oriented tests are being conducted. These tests are aimed at monitoring rail wear and fatigue under fully lubricated and dry conditions. This paper will address recent developments from these two tests, as well as review the measurement policies and other controls incorporated into the project.

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CURRENT TESTS

The final configuration selected for the HTL was in part to satisfy requirements of the defect occurrence and growth (DOG) test, and allow continued monitoring of the rail wear and fatigue (RWF) test, which is to be operated under dry conditions.

DOG Test

As the name suggests, in the DOG test rail life is examined for defect occurrences; when defects are located, the growth rate of each is determined. The defect occurrence rate is controlled in part by different types of rail quality and different levels of lubrication. The test train direction is controlled so that lubrication, which is applied by a trackside lubricator, will always be significantly greater in one area of the loop and less in another area. Figure 2 provides details of the HTL loop along with the locations of the wayside lubricators. The wear and fatigue of nearly identical test rails located in these areas are monitored for a 150-MGT period.

RWF Test

The RWF test obtains similar information, but rail life is generally limited by wear instead of fatigue. Items such as low-rail crushing and high-rail spalling are observed and documented.

USE OF DATA

With the increase in the number of railroads using or improving their lubrication programs, the replacement criteria for rails may not always be a function of wear. At locations where rail wear is a critical factor, the use of lubrication can extend the service life considerably. By examining FAST tests and comparing them with various locations in revenue service, the data obtained can be used to assist in selecting proper rails to best fit a particular situation.

LUBRICATION

Background

Before examination of the detailed wear and fatigue results, a brief review of the lubrication controls and methods is needed. Lubrication has been shown to be the single most influential item that can be used to increase rail life (*3*). Wear at the gage

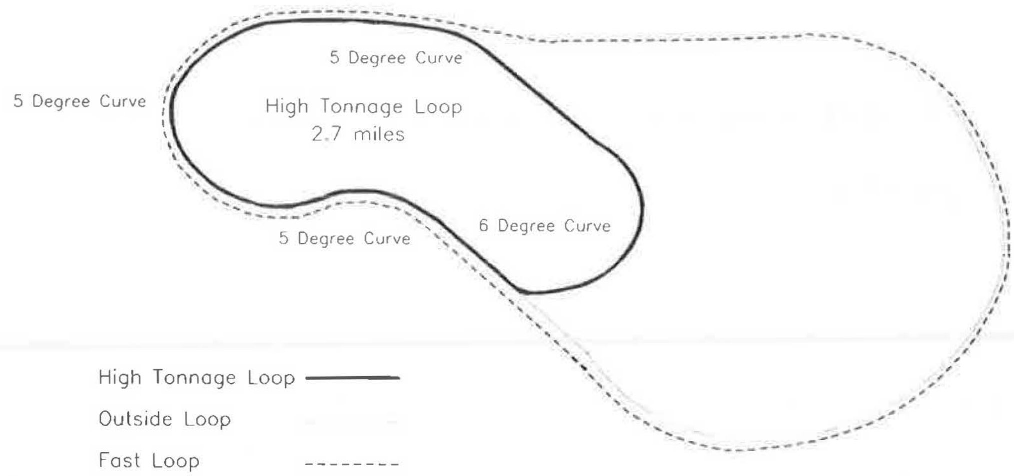

FIGURE 1 FAST loop with HTL layout.

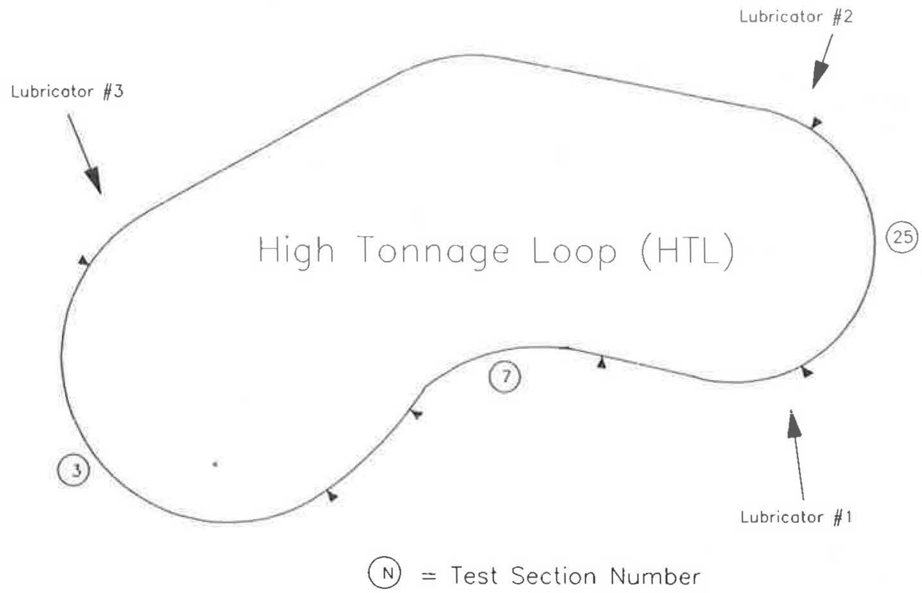

FIGURE 2 HTL loop showing lubricator locations.

face of standard carbon rail can be decreased by a factor of over 80 times by use of lubrication. (A more detailed explanation can be found in a later section of this paper.) A number of lubrication studies have been performed or are in progress to document various methods of lubrication control and application (*4, 5*).

Control of Wear

During the third rail experiment at FAST, lubrication was used to control the life of test wheels during evaluation of premium trucks. Full rail lubrication was maintained for periods of 40 MGT, followed by 10- to 15-MGT periods of dry operation. The dry periods were operated to allow accelerated wheel wear under controlled conditions. Thus, a 50-MGT block of operation was created and repeated five times for a 250-MGT test period (*2*). The results indicated significant savings in rail wear during periods of lubrication, and after evaluation of fuel purchases, a dramatic reduction in fuel consumption was also noted during the lubrication periods.

Evaluation of the data indicated, however, that a wide range of rail life could be obtained, depending on the effort applied to maintain proper lubrication. For standard carbon rail, gage face wear of 0.0251 in./MGT to 0.0016 in./MGT was observed. In addition, virtually no rail defects were observed during this 250-MGT test period. This was in sharp contrast to the previous 180-MGT period of FAST, which had been operated with virtually full lubrication from the time of rail installation and obtained a very high defect rate.

Another item added to this matrix includes a period of 107 MGT that was operated after the completion of the third rail experiment (immediately following the 250-MGT period with alternating lubricated and dry conditions). During this 107-MGT period the rail was again subjected to full lubrication under very tight controls. Absolutely no operation was permitted without gage face lubrication. Although predictions of a high defect rate were made, not one surface or subsurface defect was generated during this period. In addition, virtually no measurable wear was recorded.

The major difference between the second rail experiment and the extension of the third appears to be the condition of the rail at the time that full lubrication was initiated. In the case of the second experiment, new rail was installed and immediately lubricated, with no dry operations of any great amount. During the extension of the third experiment, rail that had already been worn to a conformal profile with the FAST wheels was in place. Unfortunately, rail of the two periods was from a variety of manufacturers and chemistries, because the original intent of these tests was, of course, to study rail wear. To better study the effect of lubrication on rail fatigue, the DOG test was proposed and is being operated.

The lubrication, rail installation, and defect pattern observed are summarized in Table 1.

Control of Defects

The use of lubrication appeared to have a direct effect on development of rail defects. The DOG test was designed to provide fatigue occurrence information on a range of rails of controlled chemistry and manufacturing processes under a variety of steadily maintained levels of lubrication. Information would be used by the analyst to determine the relationship of defect occurrence with rail type and lubrication.

As of May 1987 this test had been subjected to just over 108 MGT of traffic. The defect occurrence rate has been extremely high, and will be reviewed in a later section.

WEAR RESULTS

Measurement Techniques

FAST has developed a series of instruments designed to obtain precision wear data at selected locations on the rail head. The wear rates of the gage face and head can be determined very accurately by precise (+0.003 in.) gages. Rail profiles are utilized to determine rail shape and head area loss, but are not sufficiently precise to be used for normal wear-rate determination in a short time period (40 to 60 MGT). With the use of these precision measurement tools, accurate wear rates for high wear-rate rails (>0.005 in./MGT) can be determined in 35 MGT or less, whereas low wear-rate rails (<0.005 in./MGT) generally will require a period of 50 to 60 MGT to obtain statistically significant wear rates.

Wear information is gathered every 10 to 12 MGT from all rails located in test curves operated with no lubrication. The

TABLE 1 GAGE FACE WEAR RATES AND FIGURES OF MERIT

Metallurgy	MGT in Service	GFW (With Both Rails Dry) Wear Rate	GFW FM	GFW (With Low Rail Lubricated) Wear Rate	GFW FM
STD 289	35-111	.007132		.002082	
STD 300	35-111	.007522		.001852	
BHN 300 Avg*	--	.007327	1.0	.001967	1.0
CrMo-A	0-111	.004191	1.7	.001754	1.1
CrMo-B	0-111	.004393	1.6	.001221	1.6
CrMo-C	0-71	.003652	2.0	---**	---
HH-A	0-111	.002874	2.5	.001309	1.5
HH-B clean	0-111	.003240	2.2	.001167	1.6
HH-C reg.	0-111	.003300	2.2	.001177	1.7
HH SiCr	0-111	.002537	2.8	.001278	1.5
HH CrSiV	71-111	***	---	.002175	.90
MnSiCrV	0-71	.006204	1.2	**	---
STD 248	0-35	.00887	.82	***	---
Low Mn	86-111	***		.005421	.36

Note: Wear rates are in inches per MGT.

*Replaced Standard Carbon rail at 35 MGT as baseline rail.

**Insufficient wear to obtain statistically significant wear rate.

***Removed/Not in place during this phase of test.

GFW - Gage Face Wear Rate

FM - Figure of Merit - Std. BHN 300 Rail - FM 1.0

HH - Head Hardened Rail

data are evaluated using standard linear regression techniques to determine a rate of change per MGT of applied traffic.

Wear-rate information is highly variable between different sites; thus most FAST data reports avoid presenting only wear-rate data, electing to rank results by a figure-of-merit (FM) process. The FM rating allows one to compare the net improvement (or reduction) in the particular wear parameter of interest with that of a given standard. For example, if at a given location the baseline rail is a standard carbon rail with a gage face wear rate of 0.0012 in./MGT, this is used as the baseline rate. The FM of the standard rail is 1.0. If CrMo and head-hardened (HH) rails in the same curve have wear rates of 0.0009 and 0.0006 in./MGT, respectively, the FM of CrMo rail would be 1.33 and that of HH rail would be 2. This would permit the reviewer to determine that under similar conditions of lubrication, a CrMo rail could be expected to last 1.33 times as long as standard rail, whereas HH rail would last about 2.0 times as long as standard.

The actual wear rate obtained at any given location is highly dependent on field conditions (lubrication, unbalance speed, etc.). However, the FM allows one to judge what improvement in rail life can be expected of a premium rail over that of the baseline rail.

For FAST data, standard carbon rail [most recently, standard rail with a Brinell Hardness Number (BHN) of 285] is used as the baseline rail and by default has a FM rating of 1.0. All other rails are then compared with the standard rail.

Recent Results

The current rail wear test is located in Section 7 of the HTL track (Figure 3). Section 7 consists of a 5-degree curve 1,000+ ft long with 4 in. of superelevation on a –0.05 percent grade in the direction of predominant traffic. Train direction for the test period has been very uniform, 44 to 45 mph for the 0- to 61-MGT period and 40 mph from 61 MGT to the present (170 MGT). Almost all trains consist of four 4-axle locomotives and 70 to 80 loaded hopper cars with 100-ton capacity. A few empty cars have been periodically placed in the consist. Track is constructed with wood ties spaced at 19½ in. on center using conventional cut spikes and tie plates with timber cross ties on slag ballast 18 in. deep.

Test rails are 136/132 lb/yd American Railroad Engineering Association (AREA) section. The initial rail profile usually disappears within 5 MGT of dry operation and takes on a uniform worn profile similar to that of all FAST current rails; thus profile and section differences are not addressed in this test.

The most recent results from the dry wear portion of the HTL track are presented in Tables 1–3. As will be discussed in the next section, the change in the operation of the FAST loop to the HTL loop was a significant difference in rail wear rates. The effect of mild contamination on the low rail of the curve from lubrication of the outside rail of the HTL for defect studies was a significant reduction in the gage face wear of the high rail.

Tables 1–3 present wear rates and FMs for rails evaluated during dry high rail tests. Results for gage face wear are presented, as well as high-rail and low-rail head height loss.

Because standard carbon 248-BHN rail is no longer considered a baseline rail (generally being replaced by 285- to 300-BHN rail by the railroad industry), all data after 35 MGT are compared with 300-BHN rail. As can be seen in Table 1, under dry rail operation the 300-BHN rail provides about 20 percent more gage face rail life than standard 248 BHN. The head height loss rate for the 300-BHN rail is higher than that for 248-BHN rail, however, indicating that the rail has not sufficiently work hardened after the relatively short MGT period that these data represent. The dry, uncontaminated data for the 300-BHN rail are based on only the initial 25 MGT of traffic. A longer test period would have been desirable to obtain more statistically significant wear rates. The wear rates were relatively low, generally ¹/₁₀ of the gage face rates, resulting in data with somewhat less statistical significance than the gage

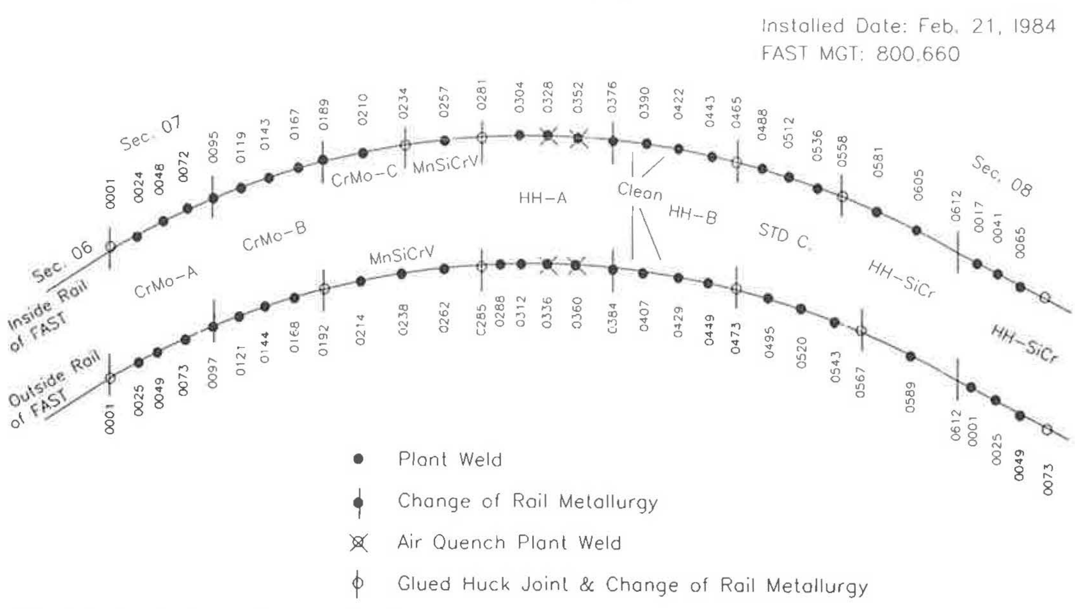

FIGURE 3 Rail wear layout—Section 7: rail metallurgy layout in relation to ties.

TABLE 2 HIGH RAIL HEAD HEIGHT WEAR RATES AND FIGURES OF MERIT

Metallurgy	MGT in Service	HL (With Both Rails Dry) Wear Rate	HL FM	HL (With Low Rail Lubricated) Wear Rate	HL FM
STD 289	35-111	.002580		.001344	
STD 300	35-111	.002201		.001053	
BHN 300 Avg*	--	.002393	1.0	.001199	1.0
CrMo-A	0-111	.000626	3.8	.000715	1.7
CrMo-B	0-111	.000871	2.7	.000884	1.4
CrMo-C	0-71	.000835	2.8	**	---
HH-A	0-111	.000283	8.4	.000242	4.9
HH-B clean	0-111	.000634	3.7	.000332	3.6
HH-C reg.	0-111	.000551	4.3	.000358	3.3
HH SiCr	0-111	.000183	13.0	.000163	7.4
HH CrSiV	71-111	***	---	.000112	1.1
MnSiCrV	0-71	.001239	1.9	**	---
STD 248	0-35	.001992	1.2	***	---
Low Mn	86-111	***	---	.001717	0.70

Note: Wear rates are in inches per MGT.

*Replaced Standard Carbon rail at 35 MGT as baseline rail.

**Insufficient wear to obtain statistically significant wear rate.

***Removed/Not in place during this phase of test.

HL - Head Height Loss Wear

face wear data. Figure 4 shows the overall test sequence in a bar chart format.

Low-Rail Contamination

The initial 61 MGT of traffic over this test zone was operated with both rails dry. At the start of HTL operations, the outside rail of the HTL was lubricated by trackside lubricators. Because the RWF section is a reverse curve, the high rail remained dry, and the low rail received some mild lubrication contamination. Measurements using a tribometer to determine the top-of-rail coefficient of friction indicated typical coefficients as follows:

Rail Location	*Top-of-Rail Friction*	*Occurrence (%)*	*Notes*
High	0.49–0.51	98	Dry
High	0.35–0.45	2	Some contamination when train is turned
Low	0.35–0.45	80	Contaminated
Low	0.20–0.25	15	Excess lubrication; misadjusted lubricator
Low	0.49–0.51	5	Dry, during dry down for rail flaw inspections

Because about 80 percent of the operation after 61 MGT is with a contaminated low rail, a separate wear rate for all rails was computed for all operation after 61 MGT. The effect of this contamination is dramatic (Table 4). In this case, FM numbers compare the same rail metallurgy between different test periods. The gage face wear for standard rail was reduced by up to a factor of 3.7, even though a very mild level of lubrication was present only on the low rail.

DEFECT STUDIES

General

Rail located on severely curved track generally will be replaced because of wear before failure from internal defects. To combat this wear, lubrication or the use of profile grinding, or both, has been suggested. At FAST, lubrication has been shown to extend rail life; however, little documented information on the effects of profile grinding on long-term rail life at FAST is available.

A profile grinding experiment, operated for 20 MGT, was performed under dry conditions in order to accelerate the wear rates. The results of this test indicated that a significant reduction in high-rail gage face wear rates can be achieved. However, the duration of the test was insufficient to determine whether fatigue problems could also be controlled. The ground profiles generally remained fully effective for only 10 MGT

TABLE 3 LOW RAIL HEAD HEIGHT WEAR RATES AND FIGURES OF MERIT

Metallurgy	MGT in Service	HL (With Both Rails Dry) Wear Rate	HL FM	HL (With Low Rail Lubricated) Wear Rate	HL FM
STD 289	35-111	.002248		.000246	
STD 300	35-111	.001791		.000243	
BHN 300 Avg*	--	.002091	1.0	.000245	1.0
CrMo-A (136)	0-111	.000726	2.7	.000244	1.0
CrMo-A (132)	0-111	.000846	2.4	.000111	2.2
CrMo-B	0-111	.000855	2.4	.000233	1.0
HH-A	0-111	.000329	6.1	.000141	1.7
HH-B clean	0-111	.000623	3.2	.000006	40.7**
HH-C reg.	0-111	.000600	3.3	.000093	2.6
HH SiCr	0-111	.000369	5.7	.000117	2.0
HH CrSiV	71-111	***	---	.000076	3.2
Mn SiCrV	0-71	.000769	2.6	**	---**
STD 248	0-35	.001754	1.2	***	---
Low Mn	86-111	***	---	.000542	0.45

Note: Wear rates are in inches per MGT.

*Replaced Standard Carbon rail at 35 MGT as baseline rail.

**Insufficient wear to obtain statistically significant wear rate.

***Removed/Not in place during this phase of test.

HL - Head Height Loss Wear

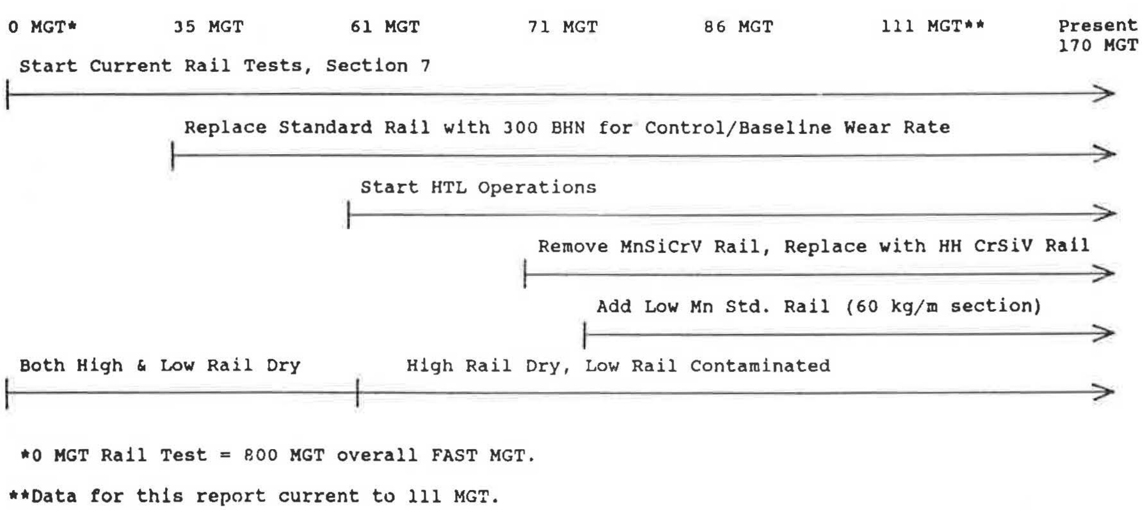

FIGURE 4 Sequence of FAST/HTL operations—rail wear test.

and were completely removed after 20 MGT (dry operation); therefore the long-term effects were not addressed. A possible repeat of part of this experiment during lubricated operation has been suggested.

The danger of rail fatigue is that its effects are generally hidden from view, and inspections require specialized techniques such as ultrasonic inspection. The use of ultrasonics is widespread in the railroad industry, but has several drawbacks. Paramount among these is that the rail-ultrasonic probe interface must be clean. Excess lubrication, dirt, or grease will interfere with normal signals and could hide potentially dangerous flaws.

TABLE 4 EFFECT OF LOW RAIL LUBRICATION ON WEAR DATA FIGURES OF MERIT

Metallurgy	High Rail GFW	High Rail HL	Low Rail HL
STD 289	3.4	1.9	9.1
STD 300	4.0	2.1	7.4
BHN 300 Avg*	3.7	2.0	8.2
CrMo - A(136)			2.9
CrMo - A(132)	2.3	.87	7.6
CrMo - B	3.5	.98	3.7
HH - A	2.2	1.2	2.3
HH - B clean	2.7	1.9	103.9**
HH - C reg	2.8	1.5	6.4
HH - SiCr	2.0	1.1	3.2
HH - CrSiV	---	---	---
MnSiCrV	---	---	---
STD 248	---	---	---
Low Mn	---	---	---

Note: FM is comparison of dry to contaminated wear rate periods. Baseline is dry period, e.g., FM = (GFW : Dry) (GFW : Lubricated). Wear rates in Table 3 were utilized for these FM values.
*Replaced Standard Carbon rail at 35 MGT.

**Data Scatter results in statistically insignificant wear rate.

Only Rails in place for sufficient time to obtain signficant wear rates during both periods are shown.

GFW - Gage Face Wear

HL - Head Height Wear

Rail defects that are monitored by the FAST/HTL program fall into two broad categories: surface defects (visible to the eye) and subsurface defects. Surface defects generally include spalls, chips, cracks, and severe metal flow. Shells, even when visible, are catalogued as subsurface defects; their origin is almost always below the surface. Major subsurface flaws include shells, transverse defects, and detail fractures.

Rail Fatigue—Dry Wear Test Zone

An important aspect of rail life is its fatigue limit. Wear life is but one limiting factor used when deciding when to replace rail. The dry regime is intended to accelerate the wear rate of rail; however, some test rails have developed surface fatigue discontinuities such as chips, spalls, and head checks before wearing out. As of this date these defects have not led to rail fatigue failure in the dry wear test Section 7 nor do they warrant removal of the rail; nevertheless, the defects are being monitored. No subsurface defects other than weld failures have been discovered in the current dry wear test to date.

Surface fatigue defects have been observed on the high rail of 300-BHN rail (after about 60 MGT of service), the low rail of SiCr-HH rail (after about 85 MGT of service), and the high rail of the CrSiVd rail. The following field observations were made:

- 300-BHN Rail—The surface conditions of concern are 45-degree head checks approximately $^5/_8$ to $^3/_4$ in. long located entirely on the gage corner of the high rail. No lubrication has ever been applied here. Coalescence of the head checks caused a significant amount of gage corner flaking over about 20 ft of the total 160-ft-long installation.
- SiCr-HH Rail—The surface conditions of concern are severe spalling and metal flow located on top of one of the low rails near the gage corner. Approximately 15 ft of the rail located in the spiral is affected.
- CrSiVd-HH Rail—Surface conditions on the top center of the high rail indicate severe spalling after about 75 MGT of service. Approximately 40 ft of spalling has developed.

Lubricated-Rail Defect Rates

The DOG test was purposely laid out to develop internal rail defects. In this respect, the experiment has been an unqualified success; after 100 MGT more than 100 internal defects have been discovered and monitored in 3,600 ft of test rail. Data collected during this test will allow the history of many flaws to be documented in detail, with post-test flaw examination and analysis. The information presented in Tables 5 and 6 indicates the effects of differential lubrication on wear and flaw generation during the initial 100 MGT of this test for a total of about 1,800 ft of track.

Table 5 provides information as to gage face wear rates of standard carbon 248-BHN rail operated dry, and from the three areas of controlled lubrication in the DOG test. Segments A, B, and C are from the 6-degree (Section 25) outside rail, whereas the dry wear data are from Section 7, a 5-degree curve. The improvement in life of 248-BHN rail from dry to moderately lubricated in this case is a factor of 74; full, continuous lubrication resulted in an improvement of at least 445 times. These are net improvements in gage face wear only.

As can be seen, rail near the lubricator has virtually no measurable wear in 100 MGT of exposure. A total of about 0.00002 in. of metal has been removed from the gage face, which is less than can accurately be measured with the TTC gages. The other rails, located farther away from the lubricator, show significantly more wear but are still much more protected than rail in the dry wear test.

Table 6 shows the total number of shells and transverse defects (TDs) discovered on the test rails that are located near and far away from the lubricator during the initial 80 MGT of testing; Table 7 shows the totals for the 110-MGT period.

Most of these rails are similar to the 285- to 300-BHN rails in wear rates, as shown in Table 5. The middle segment (B) is not included here because the gage corner of this segment was ground, and the effects of lubrication and grinding are mixed.

Tables 6 and 7 indicate that mild wear (0.00012 in./MGT) had a dramatic effect in reducing the number of shells. The TD development rate is somewhat low, but data during the most recent 30 MGT indicate that this defect rate is now increasing. It should be noted that the standard rail, located in Section 7, had a wear rate of about 0.0089 in./MGT. This rail was removed from the test after 35 MGT of traffic because almost 0.33 in. of actual gage face wear had been experienced. At the wear rate observed in the lubricated test, over 2,500 MGT would be required to obtain the same hypothetical 0.33 in. of gage face wear. Obviously, the rail fatigue life has replaced the wear life limit in this case.

In both lubricated cases, the rail metallurgy, manufacturer, and heat are identical or nearly identical (when available rail from identical heats was selected); thus the major variable has been reduced to lubrication/rail wear.

The standard carbon rail is a 248-BHN rail left over from earlier FAST tests. This and all other rail for the DOG test were new when installed. The 248 rail was installed as a control and, having been rolled in 1979, is not considered state of the art as far as rail quality. The FAST program has always utilized this type of rail, and it was selected for placement to act as a control and provide a benchmark to compare with past rail data.

Table 8 shows the head height loss wear rates for the same rails. The wear rates for the outside rail show some difference between ends of the curve, but the difference is too small to be statistically significant.

DISCUSSION

Only a small portion of the entire DOG test data base being collected has been reviewed here. A major study is also being conducted in this same area to assess the effect of grinding. Of the data presented, an overriding observation is that there is a definite difference in rail behavior between the heavily lubricated and less lubricated areas. The results initially lead one to deduce that lubrication is detrimental and brings about relatively rapid flaw occurrence in rails. The history of FAST does not necessarily agree with this, however, because rails at the end of the third metallurgy experiment were subject to the same lubrication pattern, but only after several dry periods totaling 10 to 30 MGT, depending on rail type. Table 9 gives defect history from rail lubrication.

The current DOG test is scheduled to continue a fully lubricated operation until a total of 150 MGT has been applied. At that time, significant changes in the operation of the

TABLE 5 GAGE FACE WEAR RATES OF 248-BHN RAIL

Rail Conditions	Wear Rate	FM Based on Dry
Dry*	.0089	1
Fully lubricated-near lubricator	.00002	445
Fully lubricated-1500' from lubricator**	.00006	15
Fully lubricated-2800' from lubricator	.00012	74

Wear Rate expressed in inches/MGT.

* 5 degree curve - all others 6 degree curve.

**Rail with gage face profile grinding.

TABLE 6 EFFECT OF LUBRICATION ON RAIL DEFECTS, 6-DEGREE CURVE: 80-MGT DATA

	Low Wear Rate Area* Lubrication Always Present On Top of Rail/Gage Face (High Lube Level)			High Wear Rate Area* Lubrication Only On Gage Face (Low Lube Level)		
Rail Metallurgy	No. of Shells	No. of T.D.'s	No. of Surface Defects	No. of Shells	No. of T.D.'s	No. of Surface Defects
Std. 248	13	2	5	1	0	0
Std. 264	0	0	0	0	0	0
Std. 269A	0	0	0	0	0	0
Std. 269B	0	2	2	0	0	1
Std. 269C	1	1	0	0	0	0
Std. 264D	0	0	0	0	0	0
Std. 272	0	0	0	0	0	0
Std. 273	1	1	0	0	0	1
Std. 280	0	0	0	0	0	0
Std. 283	0	0	0	0	0	0
Std. 285	0	0	0	0	0	0
Std. 289	0	0	1	0	0	1
Std. 300	0	0	0	0	0	0
Std. HH	1	0	0	0	0	0
TOTAL	16	6	8	1	0	3

*GFW of High Wear Rate : 258 Std. Rail 0.00012"/MGT

GFW of Low Wear Rate : 248 Std. Rail 0.00002"/MGT

HTL will occur, the most dominant being a change to a heavy axle load (HAL). The current limit of 33 kips per wheel will be increased to 39 kips per wheel. This will be accomplished by obtaining a new set of cars and simulating a load of what has been generically referred to as a 125-ton capacity car. Selected rails currently part of the DOG test will remain in test, and a number of new rails will also be installed.

Data analysis of flaw occurrence during the initial 150-MGT phase will be performed to determine defect origins and provide information as to rail quality required for operation in the low wear mode.

The rail wear and fatigue test will continue, with emphasis on rail life under the HAL environment. Rail wear and surface fatigue under a nonlubricated condition are expected to suffer from the HAL, especially in the head-crushing and metal-flow mode. An increase in these rates could lead to increased failures because surface anomalies turn into the rail head and cause severe spalls and chips.

FIELD CORRELATION

General

TTC has been involved with a number of field correlation studies. These sites have been offered by host railroads as locations to evaluate rail wear in the field under revenue service conditions. To date, two such studies have been completed, and the results of the most recent study indicate significant correlation with FAST results, both in the relative ranking of wear and the effects of lubrication.

TABLE 7 EFFECT OF LUBRICATION ON RAIL DEFECTS, 6-DEGREE CURVE: 110-MGT DATA

	Low Wear Rate Area* Lubrication Always Present On Top of Rail/Gage Face (High Lube Level)			High Wear Rate Area* Lubrication Only On Gage Face (Low Lube Level)		
Rail Metallurgy	No. of Shells	No. of T.D.'s	No. of Surface Defects	No. of Shells	No. of T.D.'s	No. of Surface Defects
Std. 248	48	2	12	24	0	9
Std. 264	0	0	5	0	0	0
Std. 269A	1	0	0	0	0	4
Std. 269B	0	3	4	0	1	5
Std. 269C	1	5	2	0	0	0
Std. 269D	0	0	0	0	0	0
Std. 272	0	0	0	0	0	0
Std. 273	6	1	2	0	0	3
Std. 280	0	0	0	0	0	0
Std. 283	0	0	0	0	0	0
Std. 285	0	0	1	0	0	2
Std. 289	4	0	2	0	0	1
Std. 300	0	0	2	0	0	0
Std. HH	1	0	0	0	0	0
TOTAL	61	11	30	24	1	24

*GFW of High Wear Rate : 258 Std. Rail 0.00012"/MGT

GFW of Low Wear Rate : 248 Std. Rail 0.00002"/MGT

TABLE 8 HEAD HEIGHT WEAR RATES OF 248-BHN RAIL

Rail Condition	High Rail	Low Rail
Dry*	.002	.0018
Fully Lubricated - Near lubricator	.00038	.0024
Fully Lubricated - 1500' from lubricator	.00047	.002
Fully Lubricated - 2800' from lubricator	.00041	.002

*5 degree curve - all others 6 degree curves.

Wear Rates are expressed in inches/MGT.

TABLE 9 QUALITATIVE DEFECT OCCURRENCE PATTERN—RAIL TESTS

Approximate Time Period	MGT of Test	Rails and Type of Lubrication	Defect History
1978-1979	180	Installed new rails. Full lubrication from onset of rail lubrication.	High rate of occurrence.
1979-1981	250	Installed new rails. Alternating periods of lubrication (40 MGT) and dry (10 MGT).	Very low rate.
1982	107	Same rails as above but ran only Fully Lubricated.	No defects.
1985-Present	110 & ongoing	Installed new rails. Full lubrication at all times.	High rate of occurrence.

Western Railroad Correlation

A site was offered on a western railroad that contained two 4-degree curves; seven metallurgies were installed on each curve (*6*). The overall goal of this test was to evaluate the rails as well as to determine the effect of lubrication.

Details of this test are included in the Association of American Railroads (AAR) report (*7*). The basic ranking of the rails is presented here. The eastbound curve of this test was evaluated for a total period of 42 MGT, during which the initial 23 MGT was operated dry and the final 19 MGT was operated lubricated. The test results indicated that lubrication was not fully effective; however, even the small amount applied had a dramatic effect on rail life, especially for the high wear-rate rails (standard 285 BHN). Table 10 shows the gage face wear rates of the eastbound curve for the dry and lubricated periods. As can be seen, the FMs of the dry period are considerably higher than those of the lubricated period, which follows the FAST results, in which lubrication tends to make different rails more equal in gage face wear.

Table 11 shows the effect of lubrication on gage face wear for the eastbound curve test rails. As can be seen, the standard 285-BHN rail received the most benefit. The improvement in gage face wear life with proper lubrication has been documented in the range of 10 to 80. The improvement seen at this site indicates that only marginal lubrication was present. The fact that the premium rails received little or no improvement confirms this conclusion. The overall ranking of rail fits the general trend observed at FAST, as follows:

1. Best: heat-treated rails,
2. Second: alloy rails, and
3. Worst: standard rails.

The site controls of this particular revenue service test were such that no more detailed ranking than that above can be stated with any confidence. The differential wear between ends of the curve, due to a variation in train speed and lubrication, was so great that actual numbers derived from the data cannot be utilized directly for ranking. Depending on the test period, one end of the curve or the other indicated a 25 to a −12 percent wear differential. These data are obtained from the control rail measurements obtained at each end of the test zone. The control rail gage face wear rates for the entire 42-MGT test period and the dry test period are as follows:

	Entire Test	*Dry Period Only*
West end	0.003121	0.005043
East end	0.003509	0.004041
Differential (West/East) (%)	−12	25

The results of this field service test indicate that lubrication does indeed have a dramatic effect on rail life but that to obtain valid data for rail assessment, controlled conditions are essential. The advantage of FAST is that train speed and lubrication conditions are controlled as well as documented, so that assessment of rail performance can be made with the proper statistical background.

SUMMARY AND CONCLUSIONS

FAST tests to date have provided a wealth of rail wear and fatigue data. The relative merits of different rail types have been documented under a variety of operating conditions. Ranking of rail has been standardized and compared with normal 285-type rail, allowing the user to determine the optimum rail for various conditions. The effect of lubrication has been documented. It has a dramatic effect on wear life and, if not properly controlled, can extend rail life to the point at which fatigue becomes the dominant replacement criterion.

TABLE 10 EASTBOUND DATA, GAGE FACE WEAR: WEAR RATES AND FM VALUES FOR DRY AND LUBRICATED PERIODS

	Metallurgy	Dry Period Wear Rate	FM	Lubricated Period Wear Rate	FM
1)	STD 285 BHN	.008466	1.0	.002958	1.0
2)	Chrome Moly A	.002442	3.5	.002075	1.4
3)	Flame Head Hardened	.000756	11.2	.000989	2.9
4)	Chrome Moly B	.002978	2.8	.002039	1.5
5)	Chrome Vanadium	.004698	1.8	.002971	1.0
6)	Induction Head Hardened	.001631	5.2	.001202	2.4
7)	Fully Heat Treated	.002716	3.1	.001773	1.7
8)	East Control	.004041	2.0	.002566	1.2
9)	West Control	.005043	1.7	*	*

Note:

Wear data expressed in inches of gage face wear at 5/8" below top of rail running surface.

*Insufficient wear to determine statistically significant wear rate.

TABLE 11 EASTBOUND CURVE DATA ON EFFECT OF LUBRICATION: FM VALUES FOR LUBRICATED VERSUS DRY PERIODS

1)	STD 285 BHN	2.9
2)	Chrome Moly A	1.2
3)	Flame Head Hardened	.8
4)	Chrome Moly B	1.5
5)	Chrome Vanadium	1.6
6)	Induction Head Hardened	1.4
7)	Fully Heat Treated	1.5
8)	East Control	1.6
9)	West Control	*

*Insufficient data to determine statistically significant wear rate.

Limited field correlation tests validate the basic results of FAST tests but generally are difficult to interpret because of a variety of uncontrolled influences that are part of revenue service train operation.

Future FAST/HTL rail testing will be directed at monitoring the effects of HAL on rail of different profiles operated under a variety of lubrication patterns for extended periods of traffic.

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