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2012 Results at Facility for Accelerated Service Testing

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Summary

Evaluations to improve the safety and utility of track components under heavy axle load train operation have continued at Facility for Accelerated Service Testing (FAST) located at the Transportation Technology Center (TTC), Pueblo, Colorado. Results for selected tests at FAST in 2012 when 165 MGT was accumulated are presented. The 165 MGT represents the highest yearly tonnage accumulation in the over 30-year history of the FAST Program. The increase was possible due to a newer, longer train and a temporary supplement to the base-level funding of the Association of American Railroads' Strategic Research Initiatives Heavy Axle Load Implementation Program. Highlights of testing in 2012 include:

- High-hardness premium rails had developed significant rolling contact fatigue (RCF) on the high rail after 381 MGT of unlubricated operations. The degree of RCF varied by rail type and by rail position in the curve. The rail with the best wear performance has worn about 24 percent less than the rail with the most wear.
- Intermediate hardness rails developed numerous gage-corner shells on the high rail after 381 MGT of lubricated gage face operations. The high rail was removed due to the shelling. Operating and maintenance practices at FAST may have contributed to the shelling. An investigation into the causes of the shelling is underway.
- Testing of concrete tie configurations designed to improve track strength continues to show that half-frame ties can provide increases in track strength, and reductions in the need for track maintenance. There have been some component related problems with the half-frame ties.
- Second generation thermite head-repair welds far outlived the first generation of similar welds that were evaluated. Electric-flash head-repair welds are also being evaluated. Welds made in the shop, then installed in track have outperformed the first welds made in track. In-track processes have been improved to address the performance issues.
- Testing of a continuous mainline running surface turnout showed that for the mainline, wheel and rail interaction forces are similar to open track. This type of turnout may be beneficial in locations where a great majority of the traffic is on the mainline side.

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Figure 1. HAL Train at FAST

INTRODUCTION

Tonnage was accumulated at FAST at an accelerated rate in 2012. One hundred sixty five 165 MGT were accumulated on the track components and structures being evaluated under the 39-ton axle load train (Figure 1). This tonnage is the highest tonnage recorded in a single year at FAST and exceeds the 10-year average of 132 MGT by 24 percent. Tonnage in-and-of itself of course is of little value to the railroad industry. It is the effects of the tonnage accumulation on the components being tested and what can be learned from those effects that is of interest.

Rail Evaluations

A test of premium rails developed to provide better resistance to wear and RCF began in 2010. The 10 high-hardness (413 HB average) rail types produced in Europe, North America, and Asia have accumulated 424 MGT. Table 1 lists the suppliers and types of rails in test.

Table 1. Premium Test Rails

Supplier	Rail Type(s)
Tata Steel (France)	MHH HE Mill Head Hardened Hypereutectoid
ERMS (USA)	OCP 1-Percent Carbon
JFE (Japan)	SP2, SP3 Super Pearlite 2 & 3
Mittall (USA)	HC High Carbon
Nippon (Japan)	HE-X Hypereutectoid X
Panzhihua (China)	PG4 Panzhihua Iron and Steel (Group)
voestalpine Schienen (Austria)	VAS 1, VAS 2, 400NEXT

The rails were installed in a nonlubricated 5-degree curve with 4 inches of superelevation. The standard 40-mph train operation results in approximately 1.7-inch overbalance speed.

Figure 2 shows rail wear (area loss) for the rails on the high rail of the curve through 381 MGT. There are at least two segments of each type rail in the 1,000-foot curve; the plot shows the average of at least eight profile measurements for each type of rail (there are more segments and more measurements for the rail being used as an experimental control). Note that the experimental 400NEXT rail was installed later than the other test rails and, thus, has accumulated less tonnage.

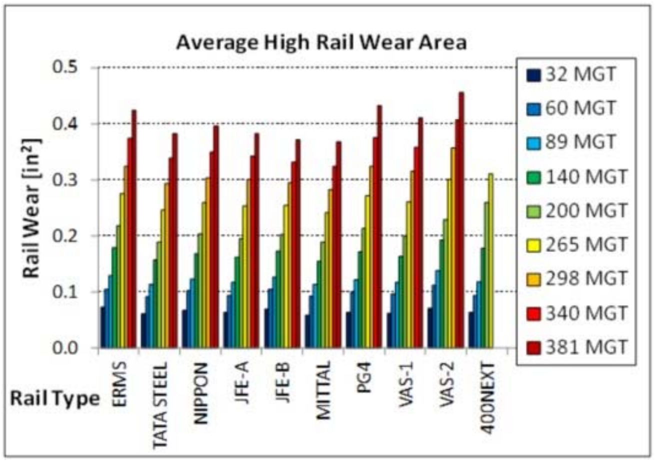

Figure 2. Premium Rail Wear Results at 381 MGT

The rail with the best wear performance has worn about 24 percent less than the rail with the most wear. Detailed statistical analysis is underway and will be included in the final report. Although there have been some minor changes in the relative wear rankings of the rails, general trends have remained fairly consistent since the 200 MGT measurements. All rail types were showing some RCF after140 MGT, and the rail had to be ground after 381 MGT to remove RCF that was severe enough to interfere with ultrasonic rail-flaw detection. Studying the effects of vehicle curving and rail metallurgy on the development of RCF has become a major focus of the experiment.

Intermediate hardness (340 HB average) rails from six manufacturers were also installed in 2010 for testing in a lubricated curve with geometry the same as in the premium rail test curve. These rails are intended to provide acceptable performance under moderately demanding conditions, at a lower cost than premium rails. Table 2 lists the types and suppliers of the intermediate test rails.

Table 2. Intermediate Hardness Rails

Supplier	Rail Type(s)
Corus (France) – 1 grade: MHH HE (as-rolled)	MHH HE (nonhead hardened) Mill Head Hardened Hypereutectoid
ERMS (USA)	IH, IH HS, SS Intermediate Hardness, Intermediate Hardness High Strength, Standard Strength
Lucchini (Italy)	IH Intermediate Hardness
Mittal (Spain)	ML Mittal's Grado MicoAleado AM Asturias
Panzhihua (China)	PG4 (nonhead hardened) Panzhihua Iron and Steel (Group)
Trinecké Zelezárny (Czech Republic)	TZ Trinecké Zelezárny

All of the intermediate rails installed in the high rail were removed after 382 MGT due to numerous gage-corner shells. The shells are being examined to try to determine failure mechanisms. However, operating conditions in the curve would have increased the propensity of any rail type to develop shells. The rail is lubricated, reducing wear. The 39-ton axle load train was operated at approximately 1.7-inch overbalance speed, increasing forces on the high rail. And, the rail was not ground after an initial light grinding. The next test of intermediate rails will include preventive, maintenance grinding.

Improved Strength Track

In 2009, TTCI installed new-design half-frame concrete ties, conventional concrete ties, and modified conventional concrete ties at FAST as part of a test of improved strength track. Tie design configurations in test are half-frame ties with under-tie pads, standard ties with under-tie pads (field installed and factory installed) at 24-inch spacing, standard ties at 24-inch spacing, and standard ties at 20-inch spacing. The half-frame ties are larger under the rail seat and have larger vertical and lateral footprints than conventional ties. The ties have accumulated 475 MGT.

Each test zone was ranked after 435 MGT using the following metrics: single-tie lateral-push resistance, rail-bending strains, loaded rail deflection, rail, tie, and subgrade accelerations, ballast degradation, and track-surface roughness. The half-frame ties were ranked number one overall. The rank was determined by summing the relative rank in each category (see Table 3). At this time, evidence of rail seat deterioration and rail pad degradation was discovered on the half-frame ties (Figure 3). The pads on the half-frame ties are different from pads typically used in North America (i.e., single-pad design, thicker and softer). These issues will be investigated in 2013.

Table 3. Tie Performance Rankings (1 is highest ranking)

Test Zone	Relative Rankings					
	Single Tie Push	Rail Bending Strain	Rail/Tie/ Subgrade Acceleration	Loaded Rail Deflection	Ballast Degradation	Surface Roughness
Zone 1 Half-Frame	1	1*	1*	4	1	2
Zone 2 Conventional Concrete	2	1*	1*	3	2	2
Zone 3 Conventional Concrete Factory Installed Under-Tie Pads	2	1*	1*	2	4	5
Zone 4 Conventional Concrete Field Installed Under-Tie Pads	2	1*	1*	2	3	1
Zone 5 Conventional Concrete 20-inch Spacing	2	1*	1*	1	3	4
*No significant difference in relative performance						

Figure 3. Tie and Pad Deterioration on Half-Frame Tie

Rail Welding

Innovative rail welding methods developed by various suppliers are being evaluated at FAST. Second generation thermite head-repair welds accumulated up to 277 MGT before being removed to allow for a new test installation. One of the eight welds was removed because of shelling after 177 MGT. In comparison, approximately 40 percent of first-generation head-repair welds had been removed by 100 MGT. Welds made directly over ties, or as repairs of electric flash butt welds, have failed at a slightly higher rate than standard installation welds. Electric flash welds are also being evaluated as a method of railhead repair.

Two sets of the electric-flash head-repair welds, one set made in the shop and one set made in the field, were installed for testing in 2011. The eight welds made in the shop have accumulated 272 MGT with no weld failures, and weld condition remains good. Two of the eight welds made in the field had failed within 160 MGT. The welds fractured with initiation at the weld collar and grinding roughness under the railhead. Proper weld finish under the head has also been shown to be critical in the performance of thermite head-repair welds.

Rail located adjacent to the weld is typically softened by the heat of the weld. This area is referred to as the heat affected zone (HAZ). A simple and inexpensive way to harden the surface of the HAZ has been evaluated and seems to be effective. The treatment includes a weld overlay on the rail with shielded metal arc weld material. The weld is performed while the rail is still hot from the thermite weld. It is ground at the same time that the thermite weld is ground, so there is no additional time from the start of the thermite weld process until the track is returned to service. Initial tests showed that the soft portion of the HAZ was reduced in width and moved away from the thermite weld. Batter in the HAZ was subsequently reduced. An expanded test started summer 2011.

Special Trackwork

In 2012, TTCI tested a continuous mainline running surface turnout at FAST. The intended application is to install this type of turnout at locations where there is very low tonnage diverging traffic at low speed; e.g., an industrial spur or setout track. The turnout (Figure 4) incorporates a lift frog to eliminate the typical flangeway gap at the frog and vertical lift switch points to eliminate the transition between switch point and stock rail.

Figure 4. Vertical-Lift Continuous Running Surface Turnout

One switch point was relocated from the gage side of the stock rail to the field side. Testing with instrumented wheelsets showed that for the mainline, lateral and vertical wheel and rail interaction forces are much lower than in conventional turnouts and are similar to open track. Lateral and vertical forces during diverging moves were as expected and were acceptable for the intended speeds. The supplier, the owner (railroad) of the turnout, and TTCI engineers identified several issues and made improvements during testing at FAST.

Future Testing

Tests are regularly updated at the direction of railroad committees to ensure that the program meets the changing needs of the industry. Tests to be started in 2013 include turnout with lateral and vertical stiffness optimized to reduce wheel/rail forces, thermite welds produced with advanced-flow molds, and the reinstallation of a high-performance concrete bridge span.