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## Update of Experiments at the Revenue Service Mega Sites

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### Summary

In 2008 and during the first quarter of 2009, engineers of Transportation Technology Center, Inc. continued the heavy axle load (HAL) revenue service monitoring program at the eastern and western mega test sites located near Bluefield, West Virginia, and Ogallala, Nebraska. The following is a summary of findings from a number of experiments in progress or that have concluded.

With gage face (GF) lubrication and top-of-rail (TOR) friction control, the premium test rails in the four test curves (6.8 to 10 degrees) at the eastern mega site continued to show excellent performance after a total of 210 million gross tons (MGT) of traffic.<sup>1</sup> Another test at the eastern mega site showed TOR friction control effectively reduced vertical rail wear and rolling contact fatigue (RCF). At the western mega site, the premium test rails in the 1-degree curve continued to show good performance after a total of 880 MGT, without TOR friction control but with some GF lubrication. For the two 2-degree test curves, after corrective grinding was performed in September 2008 to remove RCF, TOR friction control was implemented in one curve, and preventive grinding was implemented for the other curve. Both strategies are intended to prevent or delay the onset of RCF.

At the eastern mega site, two open deck bridges located in sharp curves have performed well after their decks were replaced with ballasted decks to address lateral track strength and cross-level issues.<sup>2</sup> The plastic tie test zones continued to show good performance after 250 MGT, although the entire curve was regaged due to wide gage issues in the adjacent wood tie spirals of the same curve. The elastic fastener test zones have also performed well for 225 MGT. For the wide-gap weld test, 32 test welds have performed well, although some have started to show moderate spalling or plastic flow after about 144-200 MGT.<sup>3</sup>

At the western mega site, the ballasted deck concrete bridge with concrete ties fitted with rubber pads underneath continued to perform well after 400 MGT. The rail anchor test for concrete tie track was concluded and showed no additional benefit from the anchors installed at insulated joint (IJ) locations.<sup>4</sup> Two of seven test IJs with an improved design<sup>5</sup> failed after approximately 1,000 MGT, yielding an increase in life of at least three times compared to the conventional IJ design.

The mega site testing program was established in late 2004 to consolidate various HAL revenue service experiments. The eastern mega site is located on the Norfolk Southern Railway, and the western mega site is located on the Union Pacific Railroad.

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\*\*Union Pacific Railroad

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**INTRODUCTION**

Two mega test sites were established in late 2004 to consolidate some of the HAL revenue service experiments. The eastern mega site is located near Bluefield, West Virginia, on a heavy haul track of Norfolk Southern (NS) Railway. The western mega site is located near Ogallala, Nebraska, on a heavy haul track of Union Pacific (UP) Railroad. In 2008 and during the first quarter of 2009, a number of experiments, most of which started before 2008, continued or were concluded. This *Technology Digest* (TD) gives a summary of findings from the revenue service experiments listed below:

- Premium rail performance and rail life extension
- Wide-gap weld performance
- Insulated joints, concluded
- Rail anchor for concrete ties, concluded
- Plastic ties and elastic fasteners
- Bridge approach remediation

**PREMIUM RAILS, RAIL LIFE EXTENSION**

A number of premium rails have been tested in HAL operating environments at both mega sites since September 2005.<sup>1</sup> The eastern mega site has four test curves with curvatures ranging from 6.8 to 10 degrees. Having accumulated approximately 210 MGT of traffic, all premium test rails continue to show excellent performance, with less than 4 percent rail head area loss from natural wear. There has been no RCF, and no internal defects have been identified. For all four test curves, excellent GF lubrication and TOR friction control implemented by NS have contributed to rail performance. Note that no preventive grinding, which is normally done every 30 MGT in this area, has been allowed on any of these test curves.

Also, at the eastern mega site, rails with mixed ages and mixed types in two groups of curves (six curves in each group) were monitored for TOR friction control performance effects on rail life. One group of curves has both GF lubrication and TOR friction control, whereas the other group has only GF lubrication. Measurements to date (150 MGT) have shown that implementation of TOR friction control reduced vertical wear by approximately 30 percent. In addition, TOR friction control reduced loss of rail metal from rail grinding operations, suggesting that TOR friction control reduced the occurrence of RCF. Figure 1 shows a comparison of average vertical wear on low rails between these two groups of curves, one with TOR friction control and the other without. Vertical wear shown in Figure 1 included both natural wear and loss of metal from rail grinding.

At the western mega site, where the annual HAL traffic is roughly 250 MGT, a number of premium rails have been under test since September 2005. The western mega site

has three rail test curves with curvatures in the 1- to 2-degree range. All test rails have shown excellent wear performance with projected minimum wear lives of 2,800 MGT.<sup>1</sup> But RCF became a problem for the 2-degree test curves, which required corrective grinding on the low rails at 375 MGT and then again at 690 MGT (see Figure 2). The high rails also required corrective grinding to remove RCF at 690 MGT.

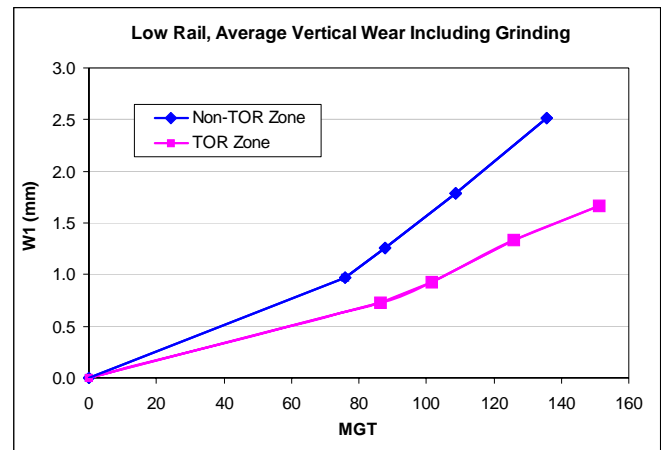


Figure 1. Effect of TOR Friction Control on Low Rail Vertical Wear

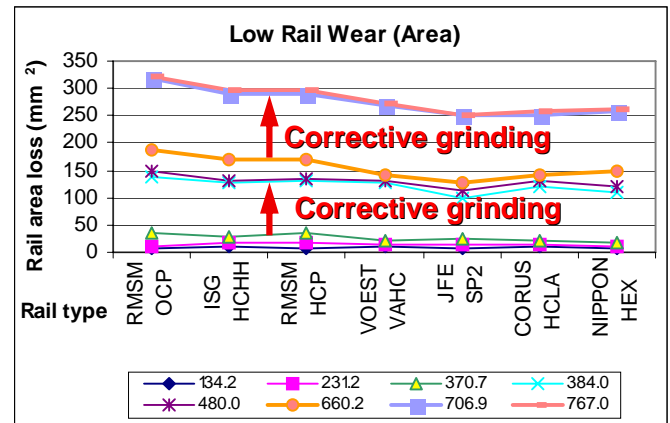


Figure 2. Loss of Rail Metal due to Natural Wear and Corrective Grinding at Western Mega Site

Starting in September 2008, the focus of the premium rail test at the western mega site was shifted to rail life extension using TOR friction control or preventive grinding. To accomplish this, one 2-degree test curve was set up with a TOR friction control unit, while a regimen of one-pass preventive grinding every 60-90 MGT was implemented on the other 2-degree curve. Because of little RCF on the 1-degree curve to date (880 MGT), no TOR friction control or preventive grinding has been implemented on this curve. Currently, performance monitoring is ongoing regarding these practices to prevent RCF and thereby extend rail life.

**WIDE-GAP WELDS**

A TD was recently published<sup>3</sup> summarizing the test results for 32 wide-gap test welds (from two different suppliers) installed at the eastern mega site. In general, these welds have performed well for approximately 200 MGT for one of the products, and 144 MGT for another product that was installed one year later. However, the majority of the test welds (70 percent) have some moderate plastic flow or gage corner spalling. Because the welds were located in the premium rail test curves, they have not received any grinding, which would normally be done on a regular basis to mitigate these surface issues. To prevent these surface condition issues from growing into defects, hand grinding was scheduled to be done in May 2009.

**INSULATED JOINTS, RAIL ANCHORS**

Eight test IJs were installed at the western mega site in the summer of 2004.<sup>5</sup> Seven IJs had an improved design; whereas, one, which failed at 330 MGT in 2006, used a traditional design. This test was concluded in 2007 in terms of measuring load environment data of these test IJs, but monitoring of their long-term performance continued. After approximately 1,000 MGT, two of the seven test IJs failed from cracked joint bars, resulting in a life at least three times as long as the conventional design. Figure 3 shows a failed IJ due to a cracked joint bar. Notice the rough running surface that generated high wheel impact forces and contributed to the breakage of the joint bar.



Figure 3. IJ Failed due to Crack Bar at 1,090 MGT

In 2007, three different IJ locations at the western mega site (two locations with older IJs and one location with new IJs) were selected to test the performance of rail anchors designed for concrete tie track. A TD was recently published describing this test and its results.<sup>4</sup> The test anchors installed at the IJ locations did not provide additional benefits in terms of reducing changes in rail neutral temperature (RNT), nor in preventing a drop in RNT when the joint bars cracked at the old IJ test location. In addition, measurements of fastener toe load indicated

little difference between rails with anchors and rails without anchors.

**PLASTIC TIES, ELASTIC FASTENERS**

At the eastern mega site, performance monitoring of two types of plastic ties installed on a 6.8-degree curve has been ongoing since November of 2004. After 250 MGT, these plastic ties continue to perform well. Figure 4 shows gage strength degradation test results using a lightweight track loading fixture for two types of plastic ties and for wood ties located in the same curve. Although showing slightly higher gage spreadings, these plastic ties have exhibited gage strength degradation trends similar to the wood ties.

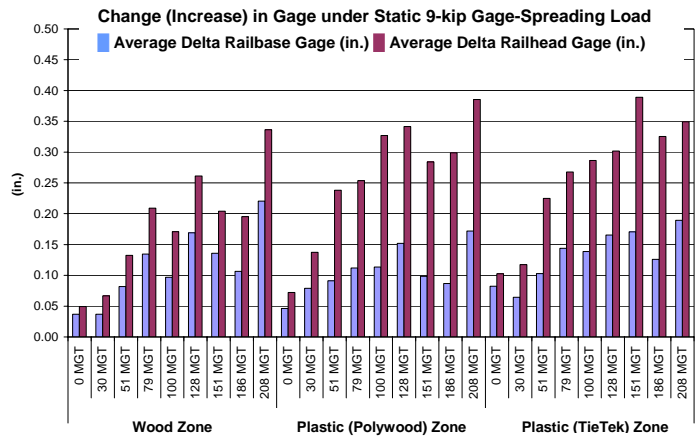


Figure 4. Gage Strength Degradation for Plastic Ties

In April 2009, the entire test curve was regaged due to wide gage issues in the adjacent spirals (equipped with wood ties) of the same curve. Note that the regaging operation for plastic ties followed the same procedure used for wood ties in terms of spike removal, spike hole filling using a synthetic material, and respiking the tie plates. Predrilling was done only for the spikes next to the side edges of the plastic ties. Except for a small crack on two ties, respiking did not cause cracking problems for plastic ties.

Also at the eastern mega site, performance monitoring of two types of elastic fastening systems installed in an 8-degree curve has been ongoing since June 2005. No major performance issues have been noticed to date after approximately 225 MGT of HAL traffic.

**BRIDGE APPROACHES**

The bridge approach test has been a major component of the HAL Revenue Service Monitoring Program at both the eastern and western mega sites, although the causes of bridge approach problems were very different at the two sites. The objective of the early phase of the test was to determine the root causes of the problems.<sup>2,6</sup> In the past two years, the focus of the testing has been to select, design, install, and monitor remedies.

At the eastern mega site, the problems are associated with open deck steel bridges located in sharp curves, which tend to have track alignment and cross-level problems, mainly because of inconsistent lateral track strength (at both the rail-tie and tie-ballast/bridge girder interfaces), skewed bridge abutment, and in some cases subgrade issues. One effective remedy is to replace the open deck with a ballasted deck, which essentially addresses the lateral track strength and cross-level support issues. Two bridges located in 10- to 11-degree curves, which had required track geometry maintenance on a monthly basis in the past, have not had any track geometry issues since deck replacement in September 2007 and March 2008, respectively.

Figure 5 shows the improvement in the lateral alignment problem (in terms of roughness, which is a mean square calculation based on actual track geometry car alignment data) for the two bridge approaches to an open deck steel bridge located in a sharp curve. As shown, alignment roughness was significantly higher prior to the remedy (deck replacement) than after the remedy.

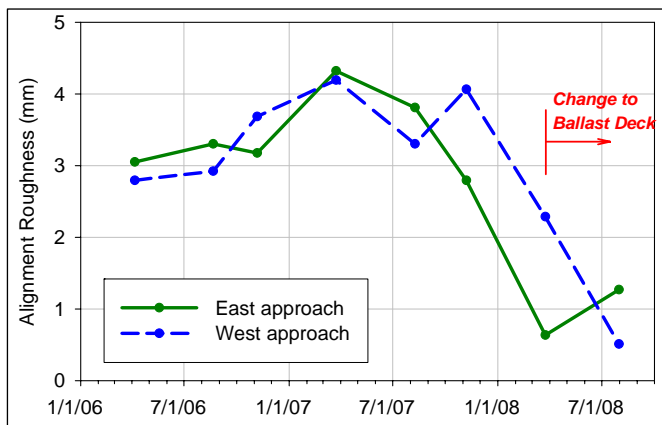


Figure 5. Improvement in Alignment due to Deck Change

Change from an open deck to a ballasted deck, although effective, is an expensive remedy and will not address bridge approach problems caused by subgrade issues. Currently, TTCI is investigating alternative remediation methods, which can be less expensive or can address subgrade problems.

At the western mega site, bridge approach problems are associated with ballasted deck bridges (both concrete and steel) with standard concrete ties. Measurements in the past have shown that the tracks on these bridges have very high track stiffness and very low damping, which is detrimental to dynamic vehicle/track interaction. High impact forces are often generated on these bridges and cause rapid track component and track geometry degradation as well as mud pumping.

To address the track stiffness and damping issues for a test bridge at the western mega site experiencing significant mud pumping and tie cracking problems (a broken rail also occurred in the approach of this bridge), standard concrete ties were changed to concrete ties fitted with rubber pads underneath them in September 2007. In addition, track drainage conditions were improved to drain rain water from the track. After approximately 400 MGT, this bridge and its approaches continue to show good performance. At this time, the performance problems previously experienced have not returned.

**FUTURE WORK**

Performance monitoring and testing will continue for the tests that have not concluded. In addition, new experiments will be initiated to address other track issues and improve track performance under HAL traffic, based on the inputs from the North American railroads and FRA.

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