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## Update of Mega Site Experiments in Revenue Service

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### Summary

Transportation Technology Center, Inc. (TTCI), in cooperation with Norfolk Southern (NS) Railway and Union Pacific (UP) Railroad, has conducted a variety of experiments at the two revenue service mega sites to assess the effects of heavy axle load (HAL) traffic on track component performance, particularly those new and alternative components intended to improve train operation safety and efficiency. The following are several main findings obtained from the experiments conducted in 2009:

- Premium test rails continue to show good performance in resisting wear and internal defect growth under HAL operations, with approximately 250 million gross tons (MGT) accumulated at the eastern mega site, and more than 1,000 MGT accumulated at the western mega site.
- The main issue associated with premium test rails is rolling contact fatigue (RCF). Preliminary test results have shown that implementation of top of rail friction control or preventive grinding is effective to prevent or delay the formation of RCF.
- At the western mega site, reducing track stiffness for the track on bridges by using concrete ties fitted with rubber pads or ballast mats between the ballast and the bridge deck, in conjunction with track drainage improvement, have been effective methods to address track geometry degradation, track component breakage, and mud pumping problems.
- After more than 280 MGT at the eastern mega site, plastic ties under test continue to be capable of withstanding HAL operations. However, tests have shown that the ends of plastic ties tend to bend upward much more than wood ties, which is characteristic of the lower bending stiffness of plastic ties as compared to wood ties. In the long run, these results may point to potential issues of pumping ballast around the ends of ties and large bending stress in the tie plates, which have indeed been observed for some plastic ties evaluated under the Facility for Accelerated Service Testing program at TTCI.
- For concrete tie tracks, missing field-side clips were found to have less effect on gage strength than missing gage side clips; whereas, missing field-side insulators had a greater effect on gage strength than missing gage-side insulators. When only clips or insulators were missing, it took a minimum of eight consecutive ties to reduce gage restraint below the allowable level. On the other hand, when both clips and insulators were missing, it took four consecutive ties to reduce gage restraint below the allowable level.

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## INTRODUCTION

Established in 2004, two revenue service mega sites have provided testing environments that supplement and complement the Facility for Accelerated Service Testing (FAST) for the HAL Research Program, in terms of train operations, track and subgrade conditions, and climate conditions.

TTCI, in cooperation with NS and UP, has conducted a variety of experiments to assess the effects of HAL traffic on track component performance, particularly those new and alternative components intended to improve train operation safety and efficiency.

In 2009, the mega site experiments were focused on the prevention of RCF on premium test rails, which have otherwise shown excellent resistance to wear and internal defect growth under HAL traffic, methods to correct bridge approach problems, and long-term performance of alternative track components, such as wide-gap welds, composite ties, elastic fastenings for wood ties, and rail anchors for concrete ties. In addition, an investigation was conducted to determine the effects of missing/failed fasteners on track gage strength. This *Technology Digest* (TD) is an update on the latest findings of these experiments.

## Premium Rail Performance

Since September 2005, eight different types of premium rails from six manufacturers worldwide have been under performance monitoring at both mega sites.

At the eastern mega site (near Bluefield, West Virginia), approximately 250 MGT of HAL traffic has accumulated on the test rails in four test curves ranging from 6.8 to 11 degrees in curvature. At the western mega site (near Ogallala, Nebraska), more than 1,000 MGT of HAL traffic has accumulated on the rail in three test curves (1- and 2-degree curves).

All test rails have shown excellent wear performance (0.08 in<sup>2</sup>/100 MGT for a 10-degree curve at the eastern mega site and 0.02 in<sup>2</sup>/100 MGT for a 2-degree curve at the western mega site). No internal defects have been identified to date. One issue associated with these premium test rails has been RCF (Li, Atkinson, and McDaniel 2008).<sup>1</sup>

Starting in September 2008, two rail life extension methods, namely preventive grinding every 70 to 90 MGT and top of rail (TOR) friction control, have been implemented in two separate 2-degree test curves at the western mega site.

To date, more than 350 MGT have accumulated. Preliminary results have shown that both maintenance strategies are effective to prevent or delay RCF from initiating. Figure 1 shows a comparison of rail surface conditions at 250 MGT. At 250 MGT following a corrective grinding with neither method implemented, severe RCF was observed, but with one method implemented no RCF was observed.

At the eastern mega site, friction control (on the gage face as well as the top of rail) was implemented at the beginning of

the premium rail test, but after 220 MGT, minor RCF has started to appear on the low rails in the two 10-degree test curves. Note that a primary test program goal is to determine the cost effectiveness of these rail life extension methods.



**Figure 1. Rail Surface Conditions at 250 MGT (top – without TOR friction control or preventive grinding, middle – with TOR friction control, bottom – with preventive grinding)**

## Bridge Approach Remedies

In TDs published earlier (Li, Duran, and McDaniel 2006; Li et al. 2007),<sup>2,3</sup> findings concerning root causes of bridge approach problems were discussed for two different types of bridges and their approaches: (1) open deck steel bridges located in sharp curves at the eastern mega site, and (2) ballasted deck concrete/steel bridges with concrete ties at the western mega site.

In the past two years, research has focused on various remedies that can effectively correct bridge approach problems. For example, converting from open deck to ballasted deck has proven effective in correcting rapid track geometry degradation problems for two bridges located in sharp curves at the eastern mega site, since their installations in late 2007 and early 2008 (Li, Meddah et al. 2009).<sup>4</sup>

At the western mega site, use of concrete ties fitted with rubber pads underneath for the track on the bridge has been effective to help correct problems for a bridge and its approaches, which previously had significant ballast breakdown and tie cracking problems.<sup>4</sup>

In 2009, research continued to select and test alternative remedies. At the western mega site, for example, another ballasted deck steel bridge with standard concrete ties had the same problems of accelerated tie cracking, ballast breakdown, and mud pumping, and was selected for remediation using

ballast mats to reduce track stiffness and increase track damping on the bridge. In June 2009, the installation of ballast mats on this revenue service bridge was completed.

To date, the performance of this bridge and its approaches has been excellent. Figure 2 shows the installation of ballast mats on this bridge.

Note that using ties fitted with rubber pads underneath and using ballast mats were initially proven effective under testing completed at FAST prior to their use at the western mega site (Akhtar, Otter, and Doe 2006).<sup>5</sup>



Figure 2. Ballast Mats for a Bridge at Western Mega Site

### Alternative Track Component Performance

A number of alternative track components are being tested at both mega sites to evaluate their ability to withstand HAL traffic. Wide-gap thermite welds, composite or plastic ties, and elastic fasteners on the wood tie track are being tested at the eastern mega site. The use of rail anchors designed for concrete tie track was tested at the western mega site. Two recent TDs (Li, Jimenez, and Kohake 2009; Gutscher, Li, and McDaniel 2009)<sup>6,7</sup> have summarized the latest test results and findings regarding rail anchor and wide-gap weld experiments. The following is an update on the other track component experiments.

Two types of plastic ties are being monitored at the eastern mega site (in a 6.8-degree curve) for over 280 MGT. These plastic ties have continued to perform well. In October 2009, measurements were taken to compare the bending behavior of plastic ties with the control; i.e., wood ties under dynamic train loads. Figure 3 shows the measured maximum downward and upward displacement results.

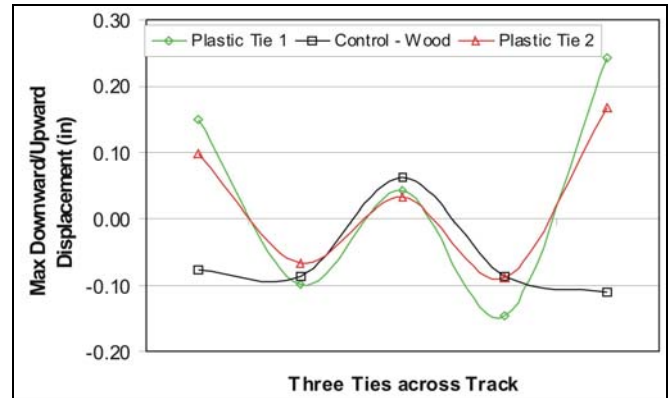


Figure 3. Deformation Behaviors of Plastic and Wood Ties

A significant difference between the plastic ties and the wood ties is that the ends of the plastic ties tend to bend upward much more than the wood ties, which is characteristic of lower bending stiffness of plastic ties as compared to wood ties. In the long run, these test results may point to potential issues of pumping ballast around the ends of ties and large bending stress in the tie plates, which have indeed been observed for some plastic ties evaluated under the FAST program (Gonzales et al. 2008).<sup>8</sup>

At the eastern mega site, performance monitoring of two types of elastic fastening systems installed on wood ties in an 8-degree curve has concluded after 260 MGT of traffic. No major performance issues were observed, except for a few broken/missing clips. For one type of fastening system, the total number of broken/missing clips was 11 (i.e., 3 percent of the clips installed), whereas for the other type, the total number was 4 (i.e., 1 percent). Nevertheless, gage strength tests showed that the test zone installed with either elastic fastening system had much higher gage strength than the control zone with cut spikes.

### Effects of Missing/Failed Fastenings

Some rail fastening components; i.e., clips and insulators for concrete tie tracks or clips and spikes/screws for wood tie tracks, will break or become loose over time under HAL train operations. As such, there are questions concerning how track integrity or gage restraining capability of rail fastenings may be compromised as a result of failed or missing fastenings and how different parts of fastenings can affect gage restraining capability (gage strength).

To help answer these questions, an experiment was conducted for concrete tie tracks equipped with SAFELOK® fastenings at FAST and at the western mega site concerning the effects of missing/failed fastenings on gage strength.

Gage strength was measured as a function of clips and insulators removed (failed), using a portable gage strength testing device that applied 9,000 pounds of gage spreading force on the railheads. Tests were conducted in tangent track, in curves (2-degree), and in both warm and cold weather. For each test, rail clips and insulators were removed one-by-one

on either the gage side, the field side, or both sides of the rail for up to nine consecutive ties. Gage widening at the center of each nine-tie test zone was measured at the railhead and at the rail base under the 9,000-pound gage spreading force (without vertical load). As noted, this was an experiment where the hold-down moment produced by the vertical force was omitted. Therefore, the results of these tests will need to be verified using the Track Loading Vehicle, which is scheduled to be completed in the first half of 2010.

Figure 4 shows the test results obtained in a tangent track section at the western mega site when the clips and insulators were removed one-by-one on both the gage and field sides of the rail. When all nine ties had their fastenings (clips and insulators) removed, the maximum gage spreading was measured at 0.97 inch.

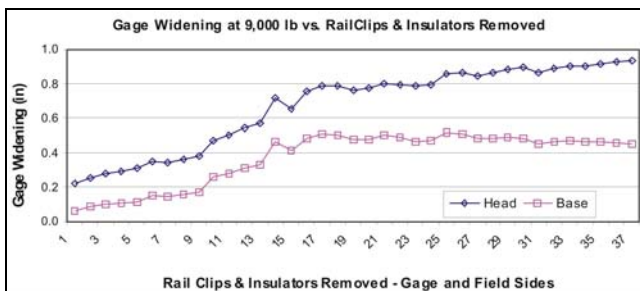


Figure 4. Gage Widening as a Function of Missing Rail Clips and Insulators

In reality, it rarely happens that all fastening components (clip and insulator) on both the gage and field side of the rail would fail at the same time. To find out how clips and insulators would affect gage strength, Figure 5 shows a summary of the test results concerning gage widening as a function of (1) missing clips on the field side, the gage side, or both the field and gage sides of the rail (three charts on the left); and (2) missing clips and insulators on the field side, the gage side, or both the field and gage side of the rail (three charts on the right). Results are given as the baseline (i.e., no failed component), missing fastenings for five consecutive ties, and missing fastenings for nine consecutive ties.

From the results shown, the following preliminary conclusions can be drawn: (1) Missing field-side rail clips have less effect on gage strength than missing gage side clips. For example, removing all field-side rail clips on nine ties (leaving gage-side clips in place) had no significant influence on gage strength. (2) Missing field-side insulators have a greater effect on gage strength than missing gage-side insulators. (3) Unless all clips and insulators on both the field and gage side of the rail are missing, it would take a large number of missing clips or insulators for eight to nine consecutive ties to reduce gage strength below the level of 0.56 inch of gage spreading at 9,000 pounds. Note that similar results were observed in the tests conducted at FAST and at the western mega site, as well as between the tests performed on tangent track and in a 2-degree curve.

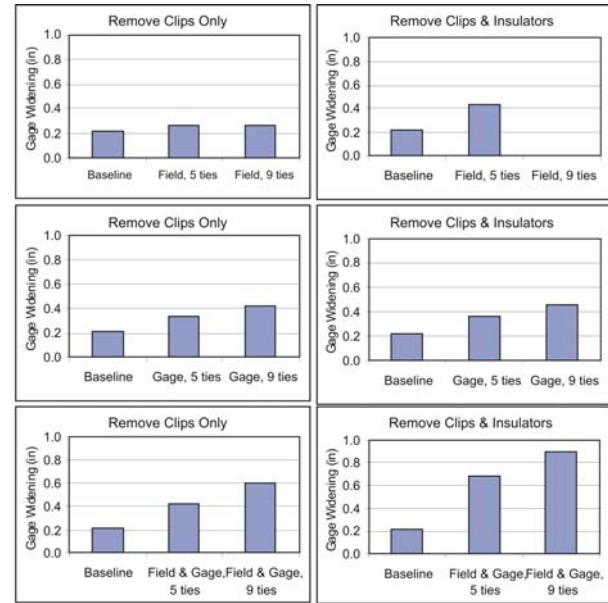


Figure 5. Effects of Missing Clips and Insulators on Gage Strength when there is No Vertical Load Applied

### Future Work

Revenue service experiments at the eastern and western mega sites will continue in order to determine the effects of HAL traffic on track components in revenue service conditions and the root causes of track problems under HAL traffic. New technologies, new track materials, improved designs, and maintenance practices will be monitored to improve train operation safety and mitigate the adverse effects of HAL traffic on track performance.

### Acknowledgements

AAR and FRA jointly fund the revenue service mega site testing program. Mega site test hosts NS and UP provide support essential to the implementation of each experiment. Many suppliers donate products for testing. TTCI personnel Rafael Jimenez, Daniel Gutscher, Rick Kilpatrick, and Gilbert Lucero carry out most of the testing efforts in the field.

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