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In-Track Performance Testing of Synthetic Tie-Plugging Materials at FAST and in Revenue Service

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Summary

Synthetic tie-plugging materials were field-tested at the Facility for Accelerated Service Testing (FAST) High Tonnage Loop (HTL) under heavy axle load (HAL) traffic at the Transportation Technology Center (TTC), Pueblo, Colorado, and in revenue service with Norfolk Southern. The R-Solutions (R-Sol) System 1 and the Willamette Valley Company's (WVC) Spikefast ES-50 synthetic materials tested at both field locations were also tested in the laboratory. The field-test at FAST was located in a 5-degree curve and the revenue service test was located in curves ranging from 6 to 12 degrees on the Dry Creek Branch between Iager, West Virginia and Richlands, Virginia. The in-track field evaluations were a follow up to the laboratory tests performed at the TTC.

All the gage-spreading strength results reported here for the field test at FAST were derived from in-motion Track Loading Vehicle (TLV) measurements.

These test findings, unless noted, relate only to the field test results at FAST:

- The first gage-spreading strength test after the test zone was regaged and plugged, before HAL traffic passed over it (0 MGT), showed a three to 14 percent increased strength.
- When the next gage strength test was conducted after 50 million gross tons (MGT) of traffic, the gage strength had increased by an average of about 46 percent in all of the sub-zones. This was likely due to some initial compression of the plugging materials and the wood fibers in the regaged holes.
- Although after 102 MGT, the gage strength in all of the sub-zones remained higher than before the installation, all of the sub-zones lost more than half of the gage strength increase that was measured at the 50 MGT cycle.
- After 102 MGT, the gage strength in the wet and dry synthetic plugging material sub-zones was higher (in one case only slightly higher) than in the wood plugged sub-zone.
- The highest increase in loaded gage during the 102 MGT life of the test occurred in the wood plugged sub-zone with a 0.21 inch increase. The difference between the wood plugged sub-zone and the synthetic material sub-zone with the least increase in loaded gage was, however, 0.12 inch.
- High spikes were not a major problem throughout the test zone.
- Based on visual observation, both of the synthetic tie-plugging materials tested filled the spike-kill holes, cracks, and voids near the holes better than the wood plugs.
- The differences in performance observed in the laboratory insertion and extraction resistance tests were not indicative of the gage-spreading strength or the loaded gage results observed in the FAST field test or the track gage stiffness measured in the revenue service test.

After 102 MGT some spot maintenance was performed in the test zone to correct widening gage. The gage widening was likely due, in large part, to the continued degradation of the ties. After the regage work was performed in several spots throughout the test zone, the test was concluded.

The long-term performance of synthetic tie plugging materials is not yet known. The results of the limited tests performed at FAST and in revenue service, however, indicate that like wooden plugs, the synthetic plugging materials provided the safety benefits of increased gage strength and tie life extension.

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BACKGROUND AND INTRODUCTION

North American Railroads have traditionally used wood plugs to fill holes left in wooden ties when cut spikes and screw spikes are removed. Recently, manufacturers of chemically engineered synthetic tie-plugging materials have been offering an alternative to the wood plugs.

In April 2003, the Transportation Technology Center, Inc. (TTCI) published the results of laboratory tests performed on three synthetic tie-plugging materials in the Components Test Laboratory.[1] In May 2003 a field test was installed on the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST) to evaluate the in-track performance of two of the same synthetic plugging materials and wood plugs in existing solid-sawn, cut spiked, wood ties under HAL traffic. In July 2003 a revenue service field test was installed on the Dry Creek Branch of Norfolk Southern (NS) in West Virginia. The general focus of the in-track field evaluations were to compare the performance of the synthetic materials with that of wood plugs and to determine if laboratory tests of cut spike insertion and extraction forces could be used to predict in-track performance. The focus of the revenue service field test was to make the same comparisons but in an environment that was different from that of FAST.

TEST MATERIALS

Table 1 shows the suppliers and the product names of the two synthetic tie plugging materials installed at both field test locations. Wood plugs were used in both cases as the control.

Table 1. Two-Part Synthetic Tie-Plugging Materials Tested

Supplier	Product Name (Two-Part Compounds)
R-Solutions (R-Sol)	System 1 Part A System 1 Part B
Willamette Valley Company (WVC)	Spikefast ES50-Resin Spikefast ES50-ISO

FIELD TEST CONDITIONS AT FAST

The test zone at FAST was located in Section 3, a 5-degree, 6-inch superelevation curve of the HTL. The test zone consisted of 650 existing wood ties occupying about 1,056 feet of track. About 358 of the 650 ties had severe checks and splits. These tie conditions allowed for an evaluation of the plugging materials in an unusually extreme environment. It is likely that many of the ties that were treated with the plugging materials would have been replaced as part of a tie replacement program had they been in revenue service.

The instrumented wheel set (IWS) load data taken in Section 3 indicates that the average and maximum lateral loading under the HAL train on the high rail are about 7 and 20 kips. On the low rail the average and maximum lateral loads are about 5 and 12 kips.

The test was installed on the HTL in a nine sub-zone configuration with a wood plug control zone and two sections of each product applied to ties in two conditions. As a result of recommendations from the Crosstie and Fastener Test Technical Advisory Group, the two synthetic materials were installed in both dry- and wet-tie conditions. TTCI's fire truck was used to thoroughly wet all the ties in the wet sub-zones. Just before treating with the synthetic material, each hole was filled with water, shown in Figure 1.

Figure 1. Willamette Valley Company's Push-Type, Single-Gun Machine in a Wet Installation Sub-zone

The distribution of the sub-zone was determined by the gage-spreading strength of the track along the 650-tie test zone using the Track Loading Vehicle (TLV) data. The gage-spreading strength is defined as the delta gage, the difference between the loaded and unloaded gage. Higher delta gage is an indication of lower gage-spreading strength.

The machine used to dispense the R-Solutions material, shown in Figure 2, was a self-propelled unit with two application guns. The Willamette Valley Company (WVC) material was dispensed using the push type unit with a single application gun, shown in Figure 1. Both machines preheat the materials between 100° F and 120° F.

Figure 2. R-Solutions' Self Propelled, Two-Gun Machine

All of the spikes on the low rail were removed and all the holes plugged with the materials before the track gage was tightened between 0.25 and 0.75 inch. All the spikes on the high rail were removed to install the plugging materials then respiked in the same holes. The spike pattern under both rails remained the same throughout the test zone – two diagonally opposed hold down spikes, two gage-side rail spikes, and one field-side rail spike.

Both suppliers provided portable, hand held two-cartridge application guns for use during rail changes and other maintenance.

FIELD TEST RESULTS AT FAST

Gage-Spreading Strength – TLV In-Motion Test

Using TLV data, the delta gage in the test sub-zones is plotted in Figure 3. The graph shows the four measurement runs taken during the 102 MGT life of the test. The pre-installation baseline run was done before any work was performed. The pre-installation run shows that the gage strength of all the sub-zones was similar with a delta gage between 0.48 inch and 0.53 inch, a range of 0.05 inch. The first TLV run after the materials had been installed was done before the HAL train passed over the zones (0 MGT) – between three percent and 14 percent increased gage strength was achieved in all the zones.

The 50 MGT run shows an increase in gage strength over the newly installed run. This initial increase after traffic was likely due to lateral track gage "settlement" as train forces compressed the plugging materials and the wood fibers in the ties. After that initial settlement, the gage strength throughout the entire test zone increased between 41 percent and 49 percent over pre-installation strength.

After 102 MGT, the gage strength in all the sub-zones remained higher than before the track section was regaged and treated with the synthetic materials and the wood plugs. Figure 3 also shows, however, that after 102 MGT more than half of the increased strength seen in the 50 MGT run over the pre-installation strength had been lost.

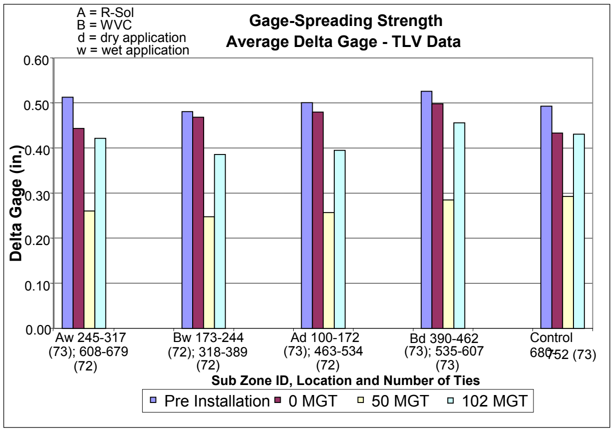

Figure 3. Gage-Spreading Strength (average delta gage) in the Synthetic Tie-Plugging Materials and the Wood Plug Test Zone

In a pre-installation versus 102 MGT comparison, the synthetic plugging materials applied in wet and dry ties performed better (in one case only slightly better) than the wood plugs relative to gage-spreading strength. After 102 MGT the gage strength in one of the synthetic material sub-zones was about 21 percent higher than before the maintenance was performed. The gage strength in the wood plug sub-zone was about 13 percent higher than before maintenance.

The highest increase in loaded gage during the 102 MGT life of the test occurred in the wood plug control sub-zone. That increase was about 0.21 inch but it was only about 0.12 inch more than the synthetic material sub-zone with the smallest increase.

Test Results at FAST versus TTCI Lab Test Results

The performance factors of the insertion and extraction forces are the ratio of the forces measured using the synthetic materials (dry and wet) to the forces measured using wood plugs. Assuming no significant effect of moisture, the wood plug lab tests were performed under dry conditions. The performance factors from lab data and field test data are shown in Figure 4. The performance factors of the field test are the ratio of the gage-spreading strength of the synthetic material test zones to the gage-spreading strength of the wood plugged test zone data.

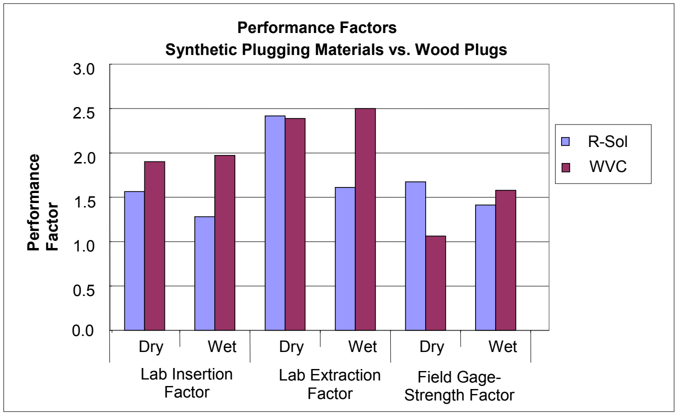

Figure 4. Performance Factors of Synthetic Materials versus Wood Plugs from the TTCI Laboratory Test and the Field Test at FAST

Figure 4 suggests that the differences in performance observed in laboratory insertion and extraction tests were not indicative of the gage-spreading strength or the loaded gage results observed in the field test.

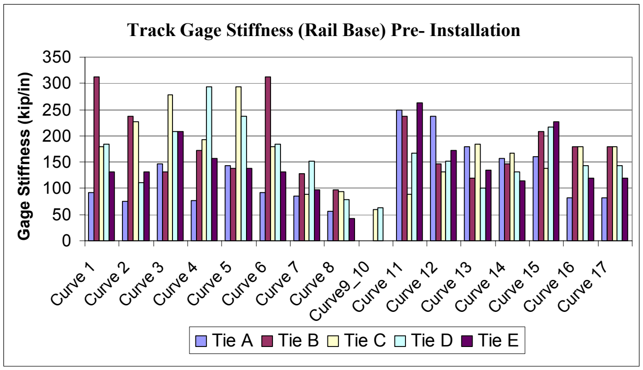

Figure 5. Pre-Installation Track Gage Stiffness in the 17 Test Curves

Static Track Gage Stiffness Field Test at FAST – Lateral Track Loading Fixture (LTLF)

The Lateral Track Loading Fixture (LTLF) was used to apply static incremental gage-spreading loads below the neutral axis of the rails to a maximum 9 kips. While the load was applied, the lateral displacement at the rail head and rail base was measured to calculate the track gage stiffness in kips/in. Six measurements were taken in each test sub-zone. The large variation in tie condition made it impossible to compare the effect of the tie plugging treatments with the number of samples taken.

Cut Spike Extraction Field Test at FAST

The variation in tie condition affected the cut spike extraction test data similarly to the LTLF test.

FIELD TEST ZONE MAINTENANCE AT FAST

High-spike maintenance is performed on the HTL when spikes are raised up 2 inches or more. During the l02 MGT life of the test, l percent of the spikes (58 in 580 ties – 10 spikes/tie) in the synthetic materials sub-zones were high and 2.5 percent of the spikes (18 in 73 ties – 10 spikes/tie) in the wood plug sub-zone were high. High spike maintenance was not a major problem in any of the test sub-zones.

After 102 MGT some spot maintenance was performed in the test zone to correct widening gage. The gage widening was likely due, in large part, to the continued degradation of the ties. After the gage work was performed in several spots throughout the test zone, the test was concluded.

REVENUE SERVICE FIELD TEST RESULTS

A revenue service test of both synthetic tie-plugging materials and control wood plugs was installed to evaluate performance under a wider range of tie conditions, track curvatures, and climatic variables than could be obtained at FAST. Seventeen curves were selected from a group of curves subjected to a rail replacement project. Test zones were established for each of the three materials.

Prior to the rail change, each curve was inspected and five ties (A through E) were selected, marked, and measured with the LTLF to establish initial track stiffness. This data shown in Figure 5 indicates a wide range of initial performance, even within the same curve.

The test curves were re-measured with the LTLF approximately 3 MGT after the rail change and installation of the plugging materials and again after 14.5 MGT. This data had a large range; the five ties measured in each curve proved to be insufficient to determine viable performance differences. Although one TLV inspection was conducted, budget limitations prevented subsequent data collection.

Before 30 MGT of traffic, the NS inspected the line and determined that overall tie conditions warranted a tie replacement cycle. The new ties would have invalidated subsequent LTLF measurement data as the load sharing between old and new ties would not be uniform. This effectively ended the field demonstration prematurely.

A larger data base consisting of more measured ties and a longer, undisturbed monitoring period would be required to determine differences in material performance in the field.

ACKNOWLEDGEMENT

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REFERENCE

1. Rafael Jimenez, Joseph LoPresti, Jim Rzonca, and Dave Davis, “Laboratory Testing of Synthetic Tie-Plugging Materials.” Technology Digest, TD-03-007, TTCI, Pueblo, Colorado, April 2003.