TECHNOLOGY DIGEST

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In-Service Evaluation of Track-to-Wire Connections for Signals

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Note: TTCI is reissuing TD-11-026 (August 2011) as TD-11-026 (Reissued Dec. 2011) because the track wire connections referred to in the originally distributed TD are being reclassified to better reflect the important variables in the test. This reclassification will assist railroad practitioners in determining which design features affect track wire performance. The new Table 1 more clearly describes the track wire connection design features tested.

SUMMARY

Through funding provided by the Association of American Railroads' Strategic Research Initiatives Program, Transportation Technology Center, Inc. monitored the performance of alternative track wire connections to determine which technologies might improve signal system reliability and ensure safe and efficient movement of rail traffic. In-track performance monitoring of existing and new technologies was first conducted at the Facility for Accelerated Service Testing (FAST), followed by installations at two revenue service environments.

Conventional track wire rail web connections, such as welded, brazed, bolted, and drilled technologies, exhibited low rates of failure. While all technologies experienced some type of failure when subjected to ballast maintenance, most had some form of wire connection remaining, suggesting that a "fused, repairable link" may offer easier repair and replacement, which is desired when the connection is required to be at the same location on the rail. Local conditions, such as access, weather related issues at time of installation, and rail preparation, all played a role in system performance and should be considered by railroad users when selecting track wire connection technologies.

Monitoring of the electrical resistivity of the test track wire connections was conducted monthly for two years at FAST and one year in revenue service. The following observations were made during the monitoring period:

- Most failures were "sudden" (in terms of a monthly monitoring schedule), with no detectable changes in resistivity to indicate an incipient failure.
  - However, epoxied connections and some base clamps did show increases in resistance before failure.
- The effect of the service environment can be assessed qualitatively by comparing the performance of the same groups of products among the three test environments (FAST—heavy axle loads in a dry climate; Northeast Corridor—high-speed passenger in a wet, corrosive climate; CSX—shared corridor in a wet climate).
  - It appears that the combination of higher frequency vibration from high-speed passenger trains and the corrosive (salt spray) environment was more severe for track wire connections than the dry climate heavy axle load and the wet climate shared corridor environments.
  - All three service environments showed the same trends, with welded and brazed connections performing best.

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INTRODUCTION

Results of industry surveys suggest signal system failures, where track wires and bond wires are attached to the rails, significantly contribute to train delays.[1,2] Review of train delay reports did not identify specific failure modes; thus, an evaluation of existing and alternative track wire connections was conducted.

BACKGROUND AND OVERVIEW

Through funding provided by the Association of American Railroads' Strategic Research Initiatives Program, performance of alternative track wire connections was conducted, assessing technologies that improve signal system reliability to ensure safe and efficient movement of rail traffic. In-track performance of existing and new technologies was conducted at FAST and at two revenue service locations. Results build on previously reported field installation techniques and laboratory screening tests.[3]

ASSESSMENT OF IN-TRACK PERFORMANCE

Samples of new and improved track wire connection technologies were installed in the track at FAST, Pueblo, Colorado, and were subjected to repeated loading of 39-ton axle load traffic. After one year of testing at FAST, examples of many of these technologies were installed at two revenue service sites. Each test installation included a pair of track wires connected to a central block to allow resistance measurements. Where feasible, at least two replications were installed for each type of technology. Resistance between the two studs was measured monthly to determine total electrical resistance (micro ohms) of each specific pair.

Figure 1. Resistance Measurement at the Amtrak Test Site

Technologies under observation were grouped into the categories shown in Table 1 to summarize performance.

In-Track Tests at FAST

In 2008, approximately 20 different technologies were installed in track at FAST for testing. Suppliers donated materials and provided technical assistance for installation. Not all technologies were installed at the same time. Figure 2 summarizes resistance data collected after 750 days of in-track monitoring. Performance for each group, as shown here, is an average resistance through a pair of rail/wire connections. This was measured with two connections in series. Most technologies performed similarly during the test at FAST; base clamp and epoxy connections exhibited the most failures, and epoxy connections exhibited a continued increase in average

Table 1. Rail Connection Groups

Rail Preparation	Rail Connection			Group	Disconnect from Rail for Maintenance[1]	Wire Disconnect Options[2]
Drill Hole	Force Fit		Wedge Pin Direct To Wire	A	Y	All
			Wedge Stud	B	N (r nut)	N/A
	Bushing with Bolted Lug			C	Y	N/A
Clean & Prepare Rail Surface	Heat	Welded >1,000°C	Web-Stud	D	N (r nut)	N/A
			Web-Direct To Wire	E	N	All
		Brazed/ Solder <482°C	Web-Direct To Wire	F	N	All
			Base-Direct To Wire	G	N	All
	Epoxy – Direct To Wire			H	N	All
	Base Clamps			I	Y	N/A

Notes:
(1) Y or N indicates ability to remove/reapply a connection at the same location without damaging rail or using special tools or supplies. (r-nut) indicates wire can be removed from the stud, but the stud remains attached to the rail.
(2) Wire connection issues. A range of wire disconnects features were utilized by participating vendors. These could be used with any of the rail connection technologies. These include:

- Crimp
- Bolted – Nut
- None – Direct to track wire – track wire lead
- N/A – shown for studded connections where existing configuration negates requirement for easy disconnect
- Fusible link, applicable to all connections (future development)

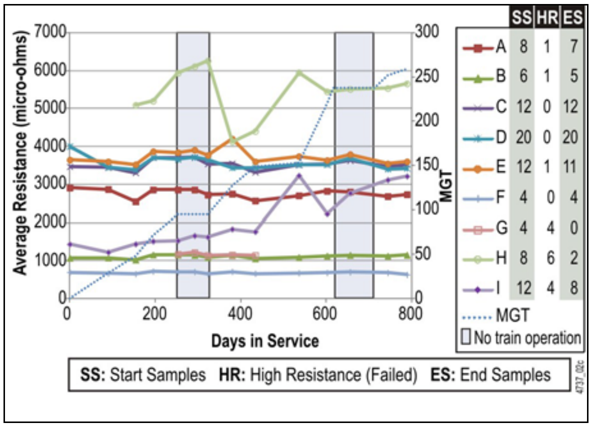

Figure 2. Summary of Average Resistance for Each Group of Connections Installed at FAST

In some cases, group averages show an increase and then a drop in average resistance, which indicates one or more connections either started to increase resistance or failed (failure is defined as resistance >20,000 ohms and/or mechanically separated from the rail). After the failed or failing connections were removed, the remaining samples produced lower average resistances.

Performance for each group is shown using the following code SS/HR/ES:

SS = Start Samples—Number of installed samples at the start of the test for that particular group of technologies.

HR = High Resistance (Failed)—Number of installations that developed high resistance (>20,000 ohms) or failed during the test.

ES = End Samples—Number of samples at the end of the test that were performing adequately (<20,000 ohms).

The code 8/1/7 for Group A, Wedge Pin Direct to Wire connections indicate eight samples installed, one failed by either falling off or developing a resistance >20,000 ohms, and seven remained in service at the end of test.

Revenue Service Installations

Components under test at FAST are subjected to a heavy axle load train operating at 40 mph, but other issues may affect performance. Therefore, two revenue service sites were selected to install some of the same track wire connection technologies being tested at FAST. Sites on the Northeast Corridor (Figure 3) at Guilford, Connecticut, and Kingston, Rhode Island, were subjected to high-speed Amtrak trains operating up to 150 mph and salty ocean air. A second site on CSX, at Folkston, Georgia, was subjected to freight trains operating up to 60 mph and Amtrak traffic operating at 70 mph. Data collection identical to that at FAST was conducted monthly by the host railroads.

In-Track Test Results

Data from the tests at FAST and in revenue service suggests that if a technology survived by remaining installed, it generally performed well within the 20,000 ohms resistance goal. At all locations, most surviving connections produced less than 4,000 ohms resistance, which suggests that surviving examples of each technology performed adequately for track circuit use.

Figure 3. Amtrak Field Site near Guilford during Installation of Test Connections

Figure 4 shows the percentage of failures to date of the original installations for the major technology categories at three test locations. Observations indicate epoxy technologies (Table 1 Group H), base clamps (I), and base brazed (G) exhibited the highest failure rates. It should be noted that the epoxy technologies are considered experimental. Base clamps were provided by a wide range of suppliers, with drive on, some screw on, and epoxy assisted experiencing failures.

Figure 5 shows a record of performance of track wire connections tested at FAST. The plot shows percent failed versus days in service. The granularity in the data is due to the relatively small number of samples in each group. The plot can be used to predict the average service life for each type of track wire connection. Also, it shows that several of the experimental products had some early failures.

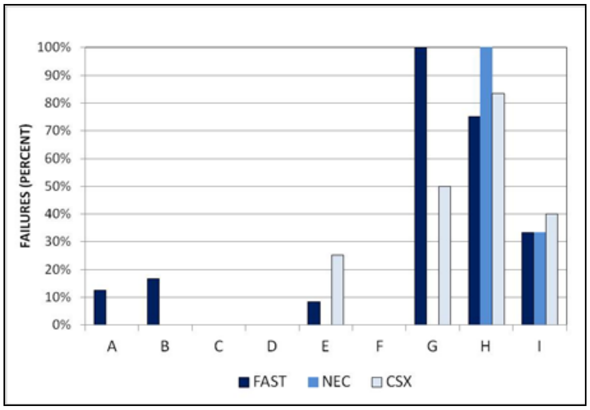

Figure 4. Percent of Original Installation Failed during Testing To Date, By Location

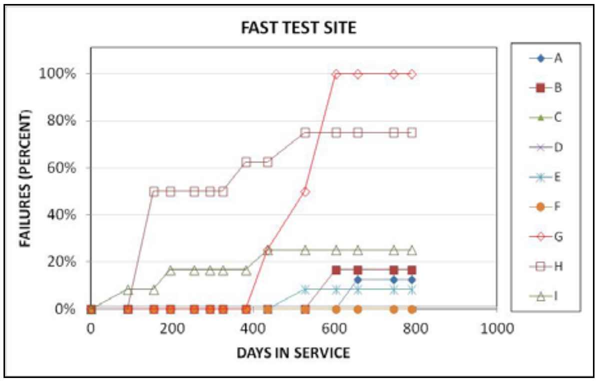

Figure 5. Percent of Failed vs. Days in Service

The effect of the service environment can be assessed qualitatively by comparing the performance of the same groups of products across the three test situations (FAST—heavy axle loads, dry climate; Northeast Corridor (NEC) —high-speed passenger, wet, corrosive climate; CSX—shared corridor, wet climate). Figure 6 shows the performance of base clamps and epoxies.

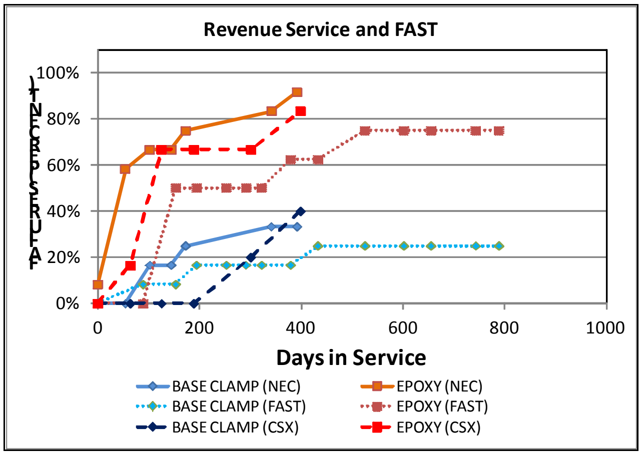

Figure 6. Base Clamp and Epoxy Failures versus Days in Service at Three Service Environments

From this comparison, it appears that the combination of higher frequency vibration from high-speed passenger trains and the salt spray environment is more severe than the heavy axle load environment at FAST.

Installation issues are a key concern of any technology involving welding or brazing; e.g., failures at the rail for base weld technology appeared to be related to surface preparation.

Field Maintenance Issues

At one revenue service site, a tie maintenance crew went through the zone soon after installation, damaging or destroying most of the connections. Most of the surviving connections had damage to the wires, and several still had the rail attachment connected to the rail web; however, the wire was broken or pulled apart (Figure 7).

Although this required reinstallation and restart of the test, the post-maintenance condition pointed to the need for future development of damage resistant track wire connections. Damage from maintenance cannot always be avoided, and the need to move connection points (especially those associated with welding or elevated rail temperature) suggests a possible improvement by making connections with a "fused, repairable link." By providing a breakaway location whereby the connection to the rail is not damaged, but sufficient wire remains to allow reattachment, could save considerable time during repair processes. To address this issue, TTCI conducted a number of pull tests in the laboratory to determine minimum wire breakaway strength. Results were reported in another *Technology Digest.*[3]

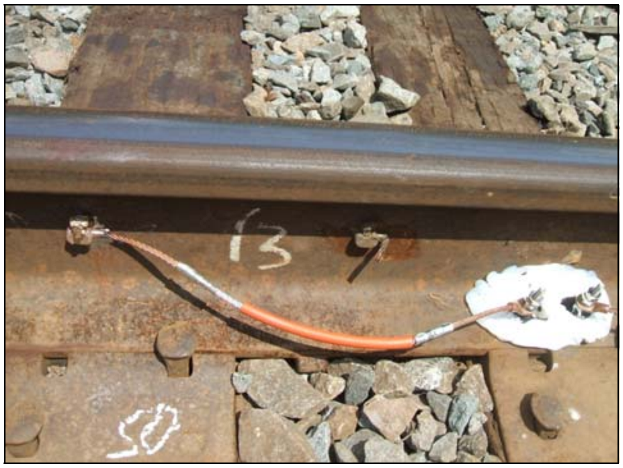

Figure 6. Replacement Wire Connection (Left) and Original Damaged Rail Attachment (Middle) after Passage of a Ballast Regulator

CONCLUSION

Conventional track wire connections, such as welded, brazed, bolted, and drilled technologies, all exhibited low rates of failure. All technologies experienced some type of failure when subjected to ballast maintenance, but most had some form of wire connection remaining, suggesting that a fused, repairable link may offer easier repair and replacement at the same location on the rail. Local conditions, such as access, weather-related issues at time of installation, and rail preparation played a role in system performance and should be considered by railroad users when selecting track wire connection technologies.

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