TECHNOLOGY DIGEST

TD-06-006

©MARCH 2006

TIMELY TECHNOLOGY TRANSFER

The work described in this document was performed by Transportation Technology Center, Inc.,
a wholly owned subsidiary of the Association of American Railroads.

Eastern Mega Site Wayside Top of Rail Friction Control Implementation Status

Richard Reiff (TTCI), Kevin Conn (NS), and Dingqing Li (TTCI)

Summary

A demonstration deploying wayside-based top of rail (TOR) friction control on the Norfolk Southern (NS) test Mega Site was monitored by Transportation Technology Center, Inc. and NS. The site at mile post 353.6 between Narrows and Bluefield, Virginia, has shown that with properly adjusted and maintained applicators, curving forces produced by loaded cars can be reduced by 30 percent or more. However, successful deployment of the TOR systems required efforts to optimize application rates and maintain the prototype wiper bars that exceeded original expectations. The demonstration site includes a 20 mile stretch of double track railroad with 14 applicator locations (28 total). Curvature ranges from 6 to 10 degrees, with loaded unit coal trains in one direction and mixed freight and intermodal equipment operating in both directions.

The prototype applicator/wiper bars were installed by NS in late 2003 and have been subjected to numerous removal and reinstallation cycles to allow for track maintenance activities, including rail grinding and tie gangs. The repeated removal and reinstallation has worn the seals that allow close fitting to the rail, resulting in leaking of the friction modifier. This leaking leads to wasted material and can produce differential left to right rail TOR friction values. A large differential in left to right rail friction can, under certain conditions, lead to increased, not decreased, curving forces.

Continued monitoring of this site will document long term effects that TOR friction control may have on rail wear, rail fatigue, and curving forces. Existing wayside lubricators have been previously optimized to provide gage face lubrication throughout the site. Vendors are being encouraged to improve applicator components and develop devices that do not require removal during routine track maintenance and repair.

This report is the first update on results from this site. Future updates will be issued after curving forces resulting from differential left/right application have been investigated, including rail wear measurements over the TOR and adjacent control line segments.

This project is jointly funded by the Federal Railroad Administration and the Association of American Railroads.

Please contact **Rich Reiff (719) 584-0581** with questions or concerns regarding this *Technology Digest.* E-mail: Richard_Reiff@ttci.aar.com

Copyright ©2006 Transportation Technology Center, Inc. Unauthorized duplication or distribution prohibited.

Introduction

As a means of reducing curving forces in a severe, heavily curved territory, Norfolk Southern (NS) elected in November 2004, to implement wayside-based top of rail (TOR) friction control (FC) over 20 miles of double track at the Mega Site between Narrows and Bluefield, VA. NS had experienced numerous cases of broken spikes and excessive high rail wear rates in this area. Thus, the decision was made to utilize a method of controlling curving forces without changing existing train operations.

The decision to implement wayside-based TOR FC was based on a number of Transportation Technology Center, Inc. (TTCI) reports[1-3] suggesting significant (30 percent) reduction in curving forces could be obtained by properly implementing a friction control system.

The initial installation was intended to demonstrate TOR friction control performance under the severe conditions of this area and to provide guidelines for NS to implement similar strategies elsewhere on their railroad. This area includes numerous 6 to 10 degree curves and experiences heavy use of locomotive sanding, end of train pushers, and a wide range of weather conditions. Included is a mix of existing wayside-based gage face lubrication used to control rail wear.

Initial results by TTCI and NS suggest that applicator system component reliability is preventing full benefits from being achieved without excessive inspection and repair labor.

Wayside TOR Layout

In the 20-mile zone, 14 pairs of wayside-based TOR applicators were installed in 2003. Table 1 summarizes applicator location and spacing.

Table 1. Applicator Spacing and Locations

TOR Applicator No.	Milepost (Approx.)	Distance Between Units
1	357.80	
2	356.15	1.65
3	354.45	1.70
4	353.30	1.15
5	352.00	1.30
6	351.05	0.95
7	349.80	1.25
8	348.35	1.45
9	346.80	1.55
10	345.40	1.40
11	343.35	2.05
12	341.95	1.40
13	340.50	1.45
14	339.00	1.50

For this demonstration, NS installed Portec Protector™ IV pumps and reservoirs, which apply a Kelsan friction modifier (FM) intended for freight use, Figure 1. When properly applied, the FM material produces a friction level of 0.3µ to 0.4µ, which improves truck steering without impacting braking or locomotive traction.

Figure 1. TOR Location No. 2

The TOR FC zone (MP 339-358) is within the 30-mile limits of the heavy axle load (HAL) revenue service implementation monitoring site.[1] This program is documenting the effects of HAL traffic in revenue service, allowing other track related performance issues to be assessed in and out of the TOR FC zone.

Train Operations and Track Construction

NS operates approximately 60 MGT on the Eastern Mega Site line with a mixture of loaded and empty unit coal trains, mixed freight, and intermodal traffic. Although traffic is bidirectional, all loaded coal trains are eastbound and generally operate on Track 1. The track alignment in this area features many 6 to 10 degree curves. Track is of wood tie construction with cut spikes. As part of the HAL revenue service test, a number of alternative DF fasteners and tie materials are also being evaluated for performance.

Monitoring TOR FC Effectiveness

TOR FC effectiveness is being measured using a number of techniques, including:

- Visual inspection
- Curving forces
- Rail friction
- Long term rail wear (to be implemented)

The use of lateral curve load measuring stations has been shown to be an acceptable method for long term assessment of TOR FC effectiveness.[2,3] By establishing baseline train curving force performance (under conditions with no TOR FC), the effectiveness of different TOR FC application rates and applicator deployment approaches can be assessed by remote monitoring. For this demonstration, NS and TTCI each installed load station sites on back to back reverse 6.2 and 6.8 degree curves, shown in Figure 2.

Curving forces developed by all trains are measured for every axle of each passing train. Data is transmitted via phone modem for reduction and analysis. For purposes of this study, a sorting routine is used to separate curving forces generated by empty and loaded (100 ton and >110+ ton) cars from every train.

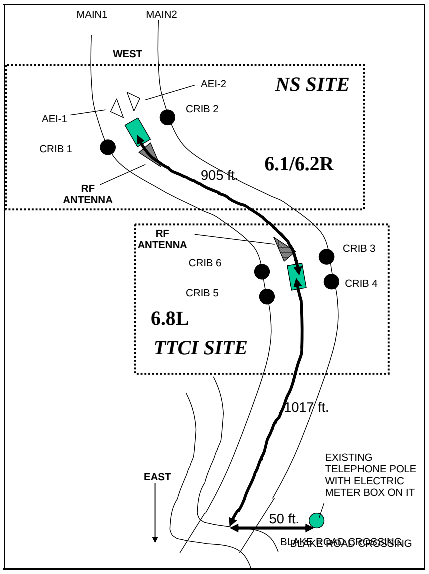

Figure 2. Load Monitoring Station Layout

For each train, the average curving force for the lead axle of loaded cars is determined, plotted with time, and placed into blocks to show performance by changes in TOR condition. The data shown in Figure 3 represents average curving forces produced by a large variety of trains and car and truck types under a range of weather and gage face lubrication conditions. Any one individual train can produce very high or very low curving forces and may not be representative of total system performance. For this reason the average from a number of trains during a long term period (2 weeks or longer) is generally utilized to determine system performance. Examples of typical data are in the Output Optimization section of this report.

Commissioning Stages

NS initially installed the 28 wayside-based TOR systems in late 2003 and early 2004. During that period, NS and the vendor representatives adjusted output rates based on results from other wayside-based TOR FC demonstrations. With the addition of the load station in early 2005, monitoring of curving forces allowed quantification of the effect of different application rate strategies.

During the first half of 2005, the wayside TOR FC units were deactivated and removed several times to support rail grinding and tie gang efforts, thus no long term effectiveness could be determined. During the last half of 2005, a parametric evaluation was conducted to determine the effectiveness of various application rates and the effect of single versus multiple applicators. Also, in mid 2005, a loss of shunt test was conducted,[4] which utilized excessive application rates during a short period to determine the effect TOR FC may have had on track circuit signal shunting. As these variations required the shutdown and reactivation at different application rates, the effect of TOR FC on rail wear has not been determined. TTCI intends to initiate rail wear measurements in early 2006 to address this issue.

Application System – Output Optimization

Early 2005 results from the load station indicated eastbound loaded train curving forces were being reduced by less than 18 percent, thus an optimization of the amount of FM applied was needed. The amount of FM product applied can be varied using two major system controls: 1) pumping duration, and 2) number of axles between pump activation. The Portec Protector™ IV pump system (which is virtually identical to that used for gage face lubricant delivery) utilizes a wheel sensor mounted to the rail to activate the system. The controller can be adjusted to operate the electric motor driven pump for various durations (0.1, 0.2, 0.25, etc. seconds) after a specified number of axles have passed, generally 8, 12, 16, etc.

During the later part of 2005, a parametric variation of pump duration/activation axles was conducted by NS and vendor representatives in an effort to optimize application rates to obtain maximum reduction in curving forces. Figure 3 shows the time period between August and December 2005, when variation in output rates and number of TOR units in operation were evaluated. Values for the average lead axle curving forces generated by loaded (hollow squares, typical 100 ton) and HAL (solid squares, 110 ton) cars are shown. Data is for Crib 6, eastbound only, Main Track 1.

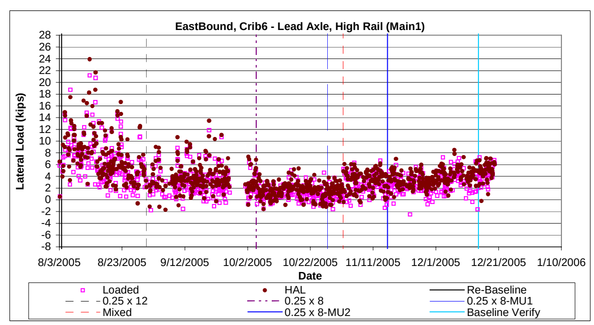

Figure 3. Time History of Average Curving Forces, Crib 6. Eastbound Loaded and HAL Cars, Lead Axle

Each train passing the site generates at least one data point (average curving forces for loaded and if present, HAL cars). As Figure 3 shows, there is a range of scatter in forces which requires monitoring a number of trains during any given period to ensure a trend is being properly monitored.

Figure 4 shows the average for loaded cars during each of the adjustment periods shown in Figure 3. In this case, there is a difference (reduction) in curving forces produced by increasing the output rate from 0.25 seconds every 12 axles (0.25x12) to every 8 axles. The baseline periods are when the TOR FC was deactivated, while the periods labeled as mixed or with a MU1, MU2 are for a variable number of applicators in operation.

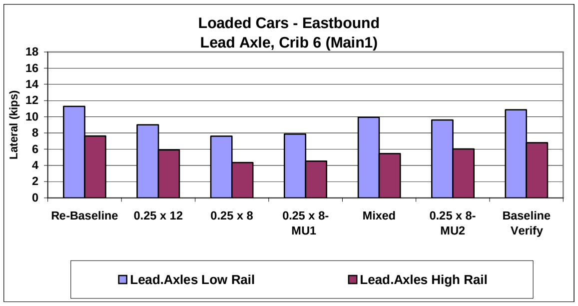

Figure 4. Crib 6, Loaded Cars, Eastbound Trains

This data shows lead axle, low rail curving forces dropped, on average, by 27 percent (11 to 8 kips), while high rail curving forces dropped by almost 45 percent (7.8 to 4.2 kips). Far fewer loaded cars operate in the westbound direction, thus the data scatter was much higher.

Loaded and HAL Cars

The data sorting routines allow separation of HAL cars from other loaded cars. Figure 5 shows the same site as in Figure 4, but for HAL cars. Data suggests a similar trend, but overall higher curving forces were generated by the HAL equipment during the baseline periods (no TOR).

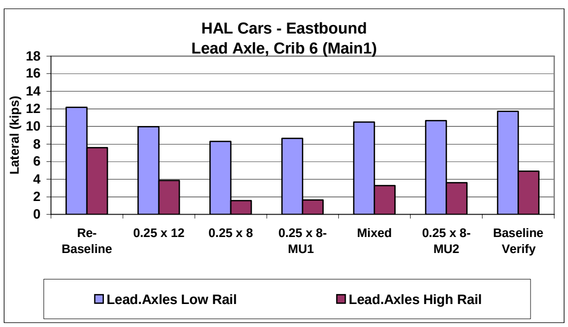

Figure 5. Crib 6 HAL Car Performance

While HAL low rail forces show similar trends to loaded cars, the high rail forces exhibited greater benefit from the TOR system than the low rail.

System Deployment Issues

The wayside applicators in this area utilized prototype, first generation applicator bars. These are shorter than current designs offer, and utilize a complex seal to maintain a close fit to the rail. During just over a year of service, most bars have been removed and reapplied four or more times to support various track maintenance efforts. This repeated reapplication has caused the seals to loose function, resulting in several bars leaking and spilling FM material onto the ballast and ties, causing waste of the product, as shown in Figure 6. In addition, the leaking is not uniform from bar to bar, resulting in a differential effectiveness from the left to right rail. The vendor is actively upgrading bar designs and improving seal performance, however NS continues to experience leakage and failures with this early design.

Figure 6. Leaking Bar, FM Material on Tie

Status, Lubrication, and Future Plans

Near term plans at this site call for initiating rail wear measurements to document the effect of TOR FM on both gage face wear and head height rail life. This will include inspections of rail surface conditions to capture any future developments. A "mini test" of differential left/right application will also be conducted to determine the effect on curving forces resulting from one side of a wayside applicator being defective. This test will also be conducted to assess an alternative measurement technique for determining TOR FC effectiveness.

Longer term plans call for continued monitoring of curving forces to determine long term effectiveness of the wayside TOR FC application systems. NS has previously implemented an optimized layout of wayside-based gage face lubricators in this area. Future rail wear monitoring will include both TOR and non TOR FC zones. This will allow the influence of TOR FC on gage face wear rates to be documented. To date, the TOR systems in place are early prototype designs that have been modified from gage face application systems. Vendors of TOR FC equipment are encouraged to develop new concepts that do not require applicator component removal for grinding or other track maintenance efforts.

Acknowledgments

The authors wish to acknowledge Rachel Anaya and Bea Rael, TTCI. Their support included downloading, plotting, and sorting data developed during the 4 month period.

References

1. Jimenez, R., D., Li, and R., McDaniel, "Preliminary Performance of Plastic Ties in Revenue Service at the Eastern Mega Site." *TTCI TD-06-005*, March 2006.
2. Reiff, R., and D. Lilley, Preliminary Placement Guidelines – TOR Friction Control Application Systems," *TTCI TD-06-002*, February 2006.
3. Reiff, R., T. Makowsky, and M. Gearhart, "Implementation Demonstration of Wayside-Based TOR Friction Control – Union Pacific Railroad, Waylong, CA," *TTCI TD-05-018*, July 2005.
4. Reiff, R., and K. Conn, "Signal Shunting Performance Related to Application of Wayside-Based TOR Friction Control. *TTCI TD-05-030*, November 2005.

Visit our website at http://www.ttci.aar.com

Disclaimer: Preliminary results in this document are disseminated by the AAR/TTCI for information purposes only and are given to, and are accepted by, the recipient at the recipient's sole risk. The AAR/TTCI makes no representations or warranties, either expressed or implied, with respect to this document or its contents. The AAR/TTCI assumes no liability to anyone for special, collateral, exemplary, indirect, incidental, consequential or any other kind of damage resulting from the use or application of this document or its content. Any attempt to apply the information contained in this document is done at the recipient's own risk.