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Wayside-based Top of Rail Friction Control – Gage Face Lubrication Issues

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Summary

To determine the effectiveness of top of rail (TOR) friction control when implemented with and without gage face lubrication (GFL), Transportation Technology Center, Inc. (TTCI) monitored rail wear performance over a 10-mile section of BNSF Railway's main line. During the first phase of implementing TOR friction control, frequent hi-rail-based application of GFL was terminated. Rail wear during this first phase of TOR friction control was determined by detailed MiniProf® measurements.

Load stations installed at three curves on the BNSF 10-mile section indicated that curving forces were reduced, by at least 40 percent, when TOR friction control was implemented. This reduction in curving forces was observed regardless of GFL condition or configuration (no GFL, marginal GFL, or short periods when hi-rail-based GFL was conducted). This level of curving force reduction is similar to other revenue service sites where GFL was first optimized before implementing TOR friction control.

Marginal GFL was present on curves monitored during the period when TOR friction control was implemented, which resulted in increased gage face wear rates for all curves. During the same period, the effect on vertical rail wear was not uniform over the identical 10-mile zone being monitored. Curves exhibited both increased and decreased vertical rail wear rates. Historically, data from other field sites show that hi-rail-based application systems often result in excess lubrication migrating to the TOR. The extent of lubricant migration and TOR contamination varies with rail profile shape and amount of product applied. This influences rail wear and addresses the observed variable effectiveness of TOR friction control.

Results confirm the need to first optimize and maintain adequate levels of GFL to control rail wear before implementing and optimizing TOR friction control.

All previous studies by TTCI of TOR friction control were conducted after GFL was improved and optimized. Historical rail wear rates for the preceding 3 years at this site, when GFL was applied by a hi-rail-based system, were determined from laser-based track geometry car data.



INTRODUCTION AND BACKGROUND

TOR friction control produces significant benefits in reduced rail wear, lower curving forces, and improved rail surface conditions at a number of field demonstration sites.¹⁻³

Questions remain regarding optimizing the balance and justification or need for combining GFL and TOR friction control. Previous wear and curving force data was collected at sites where GFL was first optimized because:

- Improperly applied GFL can contaminate the TOR with grease, resulting in reduced effectiveness of TOR friction control.
- Benefits of using TOR friction control in lieu of GFL were not documented.

As part of overall territory-wide implementation of TOR friction control, TTCI evaluated wear rates without first optimizing GFL. This was conducted in conjunction with implementing TOR friction control over a 110-mile territory of the BNSF Lakeside Subdivision.

OBJECTIVE

This project was conducted to monitor the effectiveness of wayside-based TOR friction control on a mixed freight, medium speed line with moderate curves. The BNSF Lakeside Subdivision has a variety of curves and severity, with both single and double track segments.

During the year (late 2006-2007) of TOR friction control, GFL was not applied with the same frequency and amount as in previous years. This created a period with TOR friction control application with nonoptimized GFL. Data from this (nonoptimized) period was compared to previous optimized performance to show the effect of noncontinuous GFL.

APPROACH

BNSF implemented wayside-based TOR friction control on a limited basis starting in late 2006. Initial installations concentrated on a single track segment from mile post (MP) 100 to MP 115 on the Lakeside Subdivision, with frequent 4- to 6-degree curves. For monitoring field performance, a combination of load station data and rail wear inspection results was utilized.

Previous monitoring of TOR friction control has shown that significant reductions in curving forces are obtained with proper friction control. Prior to TTCI monitoring this site, BNSF had implemented load measuring stations at several curves. However, during early phases of the TOR friction control deployment, a number of rail changes occurred, which required new load stations to be installed and new calibrations to be initiated, limiting direct back-to-back comparisons. With a change in rail (from worn to new), the effective track gage also changed. These conditions altered wheel rail contact patterns and masked changes in curving forces from improved friction control. For this reason, earlier curving force data was not utilized, and only data collected when the rail profiles remained steady during friction variations was used.

Rail wear comparisons, for GFL only and GFL with TOR friction control, required assessing a mix of databases. Earlier

wear data for a number of curves over this site was available from laser measurements conducted during periodic track geometry car runs.

Budget and time limitations for monitoring dictated that wear rates needed to be determined within 1 year. Therefore, to compare wear rates under TOR friction control (with no enhanced GFL), curves were selected that contained the same rail during both the GFL and TOR friction control periods. These rails were selected within the single track zone to ensure that accurate annual tonnage could be determined (as with most railroads, tonnage over double track segments is not recorded per track, but only the total for the line).

Track geometry car (TGC) laser-based rail wear data was available for a 3-year period prior to implementing TOR friction control over this site. A 3-year average for each of the selected curves was computed by determining rail wear for each curve during each TGC run, then plotting this by accumulated tonnage. By plotting the change in vertical and horizontal (gage) dimension against accumulated tonnage for each TGC run date, a wear rate for each curve was determined.

It is important to note that during this previous 3-year period, only a small number of wayside-based GFL applicators were functional over this route. Primary GFL was obtained by operation of a hi-rail lubricator truck 2 to 3 times a week over the entire 110-mile Lakeside Subdivision. During 2007, when TOR friction control was implemented, the hi-rail application of GFL was stopped, thus, although TOR friction control was being applied, GFL was not optimized. Wear rates and curving performance from this configuration were assessed to show the need for both GFL and TOR friction control.

Curves in this territory were selected for detailed monitoring for 2007 to determine wear rates under limited GFL, but with optimized TOR friction control. Due to the limited time available for monitoring, TTCI engineering staff used a high concentration of MiniProf profile measurements to improve measurement accuracy. By establishing eight measurement sites at each curve, a more accurate value of rail wear (change in shape) was obtained within a 35 MGT to 60 MGT period (less than 1 year).

SITE LAYOUT AND MEASUREMENT CURVES

Table 1 shows key curves, load station sites, and TOR friction control and GFL applicators within the 10-mile monitoring site. TOR friction control and GFL applicators are electrically powered. Most of the GFL applicators were not installed or in operation during the 2007 monitoring period.

Load stations are located on three curves, each approximately 6 degrees at MP 103.6, MP 104.3, and MP 104.9. Curves initially selected for measurements (to compare vertical and gage face wear rates) are listed as A to J. Due to several rail changes at specific curves during evaluation, only eight curves remained in place to provide viable comparisons.

Track geometry runs for the 2003-2006 period were obtained for analysis. For each year, two to three runs were evaluated and data obtained for average wear for the curves was selected.

During 2007, four measurement trips were conducted to inspect the site and to collect MiniProf data. At the end of 2007, data was summarized and compared to the earlier information collected from historic TGC laser-based rail wear data.

Table 1. Features within the 10-mile Monitoring Site

MP	ID	Feature	Notes
101	A	1 degree 30 minutes	
101.4		TOR applicator	
101.9	B	3 degrees	
102		TOR applicator	
102.6		GF applicator	
103.3		TOR applicator	
103.5		GF applicator	Hydraulic activated
103.6	C	6 degrees 30 minutes	Load station No. 3
104.0		TOR applicator	
104.3	D	6 degrees 06 minutes	Load station No. 2
104.5		GF applicator	
104.52		TOR applicator	
104.9	E	6 degrees 30 minutes	Load station No. 1
105	F	4 degrees	
105.4	G	5 degrees 46 minutes	
105.8		TOR applicator	
106	H	3 degrees 02 minutes	
106.5		GF applicator	
107	I	4 degrees 28 minutes	
107.3		TOR applicator	
107.5	J	5 degrees 30 minutes	
107.8		TOR applicator	
109		GF applicator	Not activated

DATA RESULTS — CURVING FORCES, WEAR

Figures 1 and 2 show the curving force data. During 2007, several events occurred where TOR friction control systems were activated, deactivated, or output changed, and different GFL systems were operated, which affected resulting curving performance. These can be broadly categorized as:

- Baseline (no TOR friction control or no GFL)
- TOR on (various application rates)
- GFL applied by hi-rail applicator for limited time periods after rail grinding

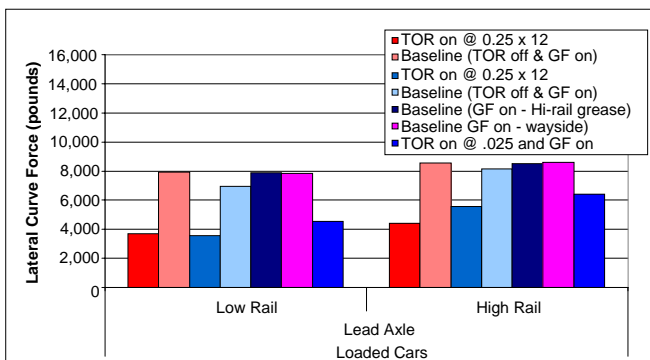


Figure 1. Curving Forces for Eastbound Trains, Site at MP 103.6

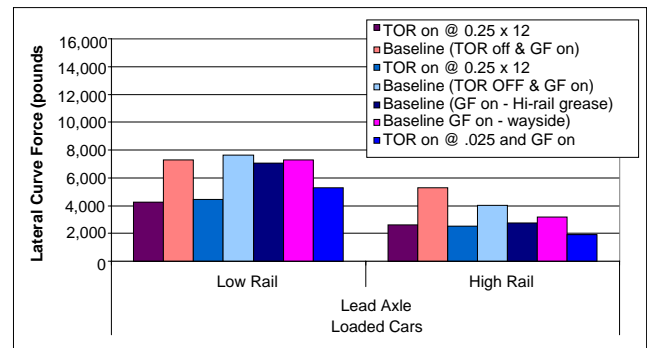


Figure 2. Curving Forces for Westbound Trains, Site at MP 103.6

During most of 2007, no changes in data collection or rails occurred, allowing curving forces at each site to be compared to changes in friction and lubrication policy throughout the year. Figure 1 (eastbound trains) and Figure 2 (westbound trains) show the curving forces generated by trains passing load station No. 3. Data suggests that when the TOR friction control units are shut down, curving forces increase considerably. In some cases (eastbound trains on the low rail), curving forces virtually double, while for westbound trains, curving forces increase nearly 60 percent.

Likewise, when TOR is reinstated, curving forces are reduced by 38 to 53 percent, again depending on location and direction. Overall, this site behaves identical to other TOR friction control monitoring sites; curving forces reduce by at least 40 percent when TOR friction control is activated.

Key issues to be addressed are: (1) the reduction in curving forces with TOR at this site was achieved regardless of the state of GFL and (2) do benefits such as reduced rail wear, observed at other sites, occur even though there is no active GFL?

By evaluating historical rail wear rates at this site when generous lubrication was present (from hi-rail application for the period prior to implementing TOR) compared to wear rates during 2007 (when hi-rail application of GFL was suspended), the ability of TOR to control rail wear without supplementary GFL can be determined. Results suggest that lack of GFL has a significant detrimental effect on overall rail wear. Figures 3, 4, and 5 show this for vertical wear rates (high and low rails), and gage face for high rail, as depicted in the comparison letter codes in Figures 3 through 5 that correspond with Table 1.

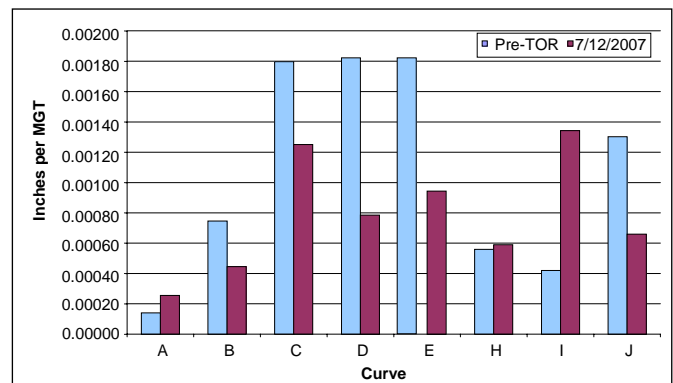


Figure 3. Vertical Wear Rates, Low Rails

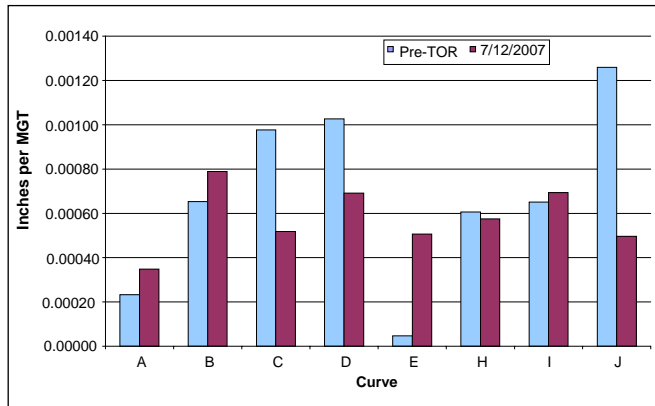


Figure 4. Vertical Wear Rates, High Rails

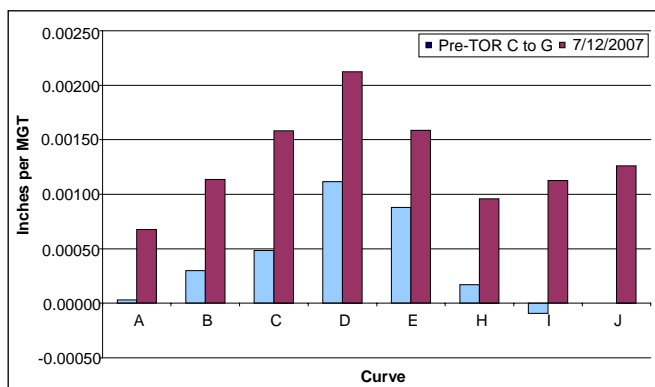


Figure 5. Gage Face Wear Rates, High Rails

For each curve, the average rail wear rate for the pre-TOR period, as determined from 3 years of TGC laser-based inspections, is compared to that measured in 2007. In all figures, the light blue bars represent wear rates for each curve during the pre-TOR period with normal GFL, whereas the maroon bars represent wear rates with TOR but little or no GFL.

Vertical wear rate performance, for both high and low rails, during the TOR friction control period compared to the GFL-only period was mixed, with some curves exhibiting much lower wear rates and others similar or higher. However, during the TOR friction control period, gage face wear exhibited much higher wear at all curves monitored. As hi-rail application of lubricant is often associated with excess lubricant migrating to the TOR, vertical wear of some curves was likely being benefited during the prior GFL-only period. Field experience with hi-rail application systems suggests lubricant pattern and migration is heavily dependent on rail wear and shape, supporting the rationale for observed variations in vertical wear rates.

CONCLUSIONS AND FUTURE

Data suggests both GFL and TOR friction control are needed to obtain full benefits of controlling rail wear. Applying only TOR friction control, with little or no GFL, results in a significant increase to gage face rail wear rates. At the same time, there is a limited benefit to vertical wear rates. The use of

TOR friction control does, however, have a significant influence on reducing curving forces, regardless if GFL is present or not. Future plans are to monitor this same area after TOR friction control with both optimized GFL and TOR; however, current budget limitations have prevented this from being monitored.

IMPLICATIONS TO TOR FRICTION CONTROL DEPLOYMENT

Railroads considering adapting and implementing TOR friction control (wayside or mobile based) should first ensure GFL is optimized. This includes maintaining proper friction values on gage side (less than 0.25μ), while limiting migration of lubricant to the TOR. Once this is established, implementing TOR friction control will not only reduce curving forces, but will improve rail life and rail surface conditions. Guidelines for friction control are currently being updated in TTCI reports and are included in Chapter 4 of the American Railway Engineering and Maintenance-of-Way Association *Manual for Railway Engineering*.^{4,5}

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