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Optimization of Top of Rail Application System Configuration

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Summary

A more cost effective application system configuration for top of rail (TOR) friction control has been demonstrated with funding provided by the Association of American Railroads' Strategic Research Initiatives Program and the Federal Railroad Administration, with cooperative efforts from the Union Pacific Railroad, Kelsan Technologies Corporation, and Portec Rail Products, Inc.

For this demonstration, the standard 4-bar application system was replaced with a lower cost 2-bar system. Other ongoing and previous efforts to reduce costs of applying TOR friction control materials have included optimizing applicator spacing, applicator output rates, and evaluating lower cost friction control materials. Benefits from controlling TOR friction have been demonstrated in numerous trials using wayside, hi-rail, and locomotive-based applicator systems.^{1,2,3} The primary benefits have included reduced curving forces and reduced rail wear rates

A segment of the Union Pacific mainline located near Tehachapi, CA has been monitored for the last 3 years under a variety of friction control conditions. Two 5-mile segments were controlled with different friction control/lubrication methods. The control zone was upgraded only by optimizing gage face lubrication (GFL), while a nearby and a nearly identical in alignment and gradient segment was upgraded with both optimized GFL and TOR friction control. During the most recent monitoring effort, the primary goal was to determine if previous benefits observed in the TOR segment could still be obtained with an optimized (reduced cost) TOR application system.

Field observations and data confirm that the application of TOR friction control materials through both 4-bar and 2-bar applicator systems provided similar benefits. Both short-term (train-by-train reductions in curving forces) and long-term (rail wear and rail surface) performances were similar under both applicator configurations. Benefits of using the 2-bar system included:

- Lower equipment purchase costs
- Fewer working parts
- Reduced maintenance and adjustment requirements
- Decreased likelihood of clogging or blockage

However, a short period of time occurred during which GFL and/or TOR friction control may not have been maintained to full effectiveness. This was seen by increased rail wear rates, especially to the gage face. Therefore, an important result confirms that to achieve benefits from controlling TOR friction, GF lubrication must also be optimized and maintained throughout the entire area. The application of TOR friction control in this area has shown to increase rail wear life by a factor of 2 to 3 times, depending on gage face or vertical wear limits.



BACKGROUND AND OBJECTIVES

Benefits from controlling TOR friction have been demonstrated in numerous trials using wayside, hi-rail, and locomotive-based applicator systems.^{1,2,3} Primary benefits provided by TOR friction control systems have included reduced curving forces and reduced rail wear rates.

Issues limiting widespread implementation of TOR friction control systems include the cost of TOR material/product, unknown long-term performance/reliability of application equipment, and documentation of the need for concurrent gage face lubrication (GFL), to provide observed benefits. This report summarizes the results from monitoring TOR friction control systems after nearly 200 MGT of traffic over three years. This includes long-term wear results, as well as the effectiveness during a recent effort to reduce application system costs. These results are based on performance monitored at a site with two segments of nearly identical curves and rail. One zone was equipped with only GFL systems and the other supplemented GFL with wayside-based TOR (Figure 1).

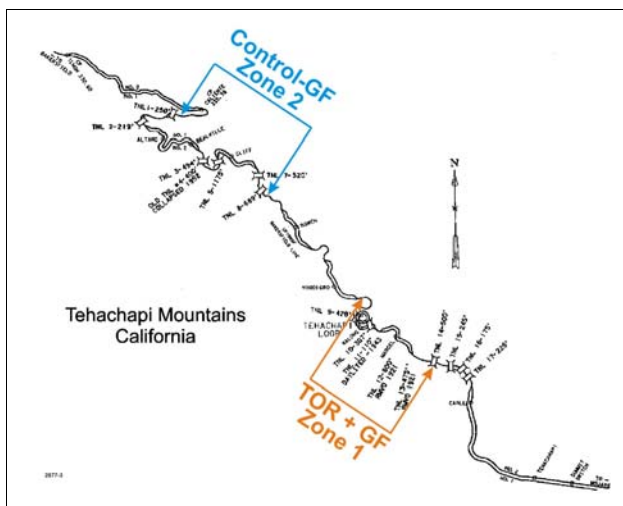


Figure 1. Site Layout showing Curves and Positions of Wayside TOR and GF Applicators

Test Site

Technology Digest TD-05-018 provides a detailed description of the test site near Walong, California.¹ Key parameters of the curves monitored for this test include:

- All curves located on 2-percent grades
- All curves at 10 degrees
- All rail of the same type: Nippon Head Hardened 141AB, installed in August 2005
- All locations optimized with wayside-based GF lubrication
- Same trains, speeds, and general cant deficiency were used in Zone 1 (TOR and GF) and Zone 2 (control with GF only)

Figure 1 shows the track layout in the test area, breaking down the two zones. Zone 1 was equipped with TOR friction control applicators and optimized GF lubrication, while Zone

2 was equipped with optimized GF lubrication only. Within each zone, eight curves were selected for monitoring that had reasonably the same superelevation and curvature. With one exception, all were located on single track. Wear data from the one curve located on the mainline portion of a siding is not included as the tonnage was not identical to the other curves.

After new rail was installed in mid-2005, GF lubrication systems were installed in both zones utilizing state-of-the-art Portec Protector IV™ solar-electric wayside GF applicators applying Lithium-based MoS₂ grease, while TOR implementation was initiated in Zone 1 only. Note that the layout of the GF lubricators is identical for both zones.

TOR System Optimization

For the most recent monitoring effort, the primary goal was to determine if previous benefits could still be obtained with an optimized (reduced cost) application system. This was accomplished by monitoring curving forces, rail wear and rail surface performance during a period with the same amount of TOR material being applied through a reduced number of TOR applicator bars at each site, and comparing that to previous experience.

When the TOR friction control concept was first developed, prototype and subsequent production application configurations followed GF lubricator practice with four applicator bars (two per rail) at each applicator site. This configuration ensured the entire circumference of the wheel tread was exposed to freshly applied TOR friction control material from each passing wheel. Two 5-foot-long bars were used at each rail to create a 10 foot-long application area, the approximate circumference of 36-inch diameter wheels.

To reduce equipment purchase and installation costs, systems with one bar per rail (2-bar system) have been demonstrated on a limited basis, but at locations with less severe conditions (e.g., curvature and braking). Initial findings from these 2-bar sites suggested similar reductions in curving forces were obtained when the same amount of TOR material was applied when using the original 4-bar system. Advantages of a 2-bar system (single bar/rail) include reduced initial cost, maintenance, and repairs. The Tehachapi TOR friction control site was selected to demonstrate the effectiveness of 2 bar versus 4 bar benefits at a severe mountain territory.

KEY RESULTS
Curving Forces

Lateral curving forces on a 10-degree curve near milepost 352 at this site have been monitored since 2005. Curving force data provides immediate information on the effectiveness of TOR friction control applicators. Results previously reported show curving forces produced by loaded cars for southbound trains operating in the uphill direction were reduced by 31 to 58 percent with an activated TOR control applicator.¹

At this site, the benefit observed on northbound trains was not as high, with overall average curving force reductions of

about 10 percent when a TOR control applicator was activated. Two factors likely contribute to this difference in performance:

- Train braking (northbound trains)
- Distance from nearest TOR applicator

Northbound trains often use air braking to supplement dynamic engine brakes, which results in TOR material being wiped from the wheel tread. Northbound trains also travel a longer distance from the closest TOR applicator to the load station — almost 1 mile. Southbound trains pass over a TOR applicator about 1200 feet before the load measurement station.

Provided other issues (e.g., train speed, load, and superelevation) do not change, long-term average curving forces will reflect changes in effectiveness of TOR friction control. During the period between 84 and 184 MGT, changes were limited to variations in TOR friction control, with uniform GF lubrication at all locations, as follows:

- 84-128 MGT – 4-bar TOR applicators
- 129-141 MGT – rail ground, adjust TOR for 2 bars
- 142-184 MGT – 2 bar TOR applicators

By measuring curving forces and rail wear during the above major periods, short- and long-term effectiveness of the 2-bar versus 4-bar applicator configurations can be shown. Figure 2 shows the average curving forces for six periods, (one period with no TOR application, three with 4-bar application, and one period with 2-bar application).

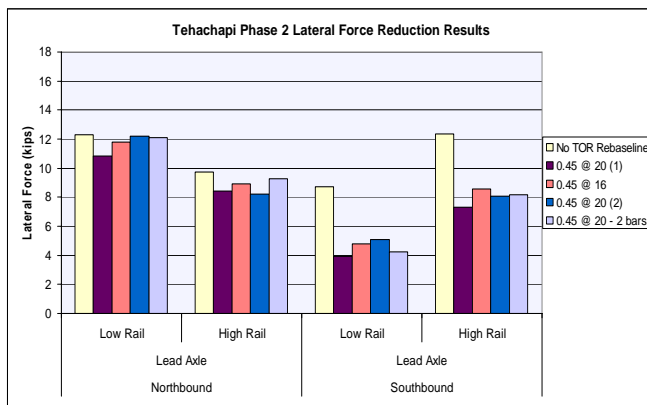


Figure 2. Curving Force Summary

Figure 2 also shows that for either train direction the highest forces occurred when TOR application was ceased. The largest benefit was on southbound trains. The legend indicates applicator pump operating duration in seconds first, followed by the number of passing axles between activation, thus 0.25@20 indicates the pump operated for 0.25 seconds every 20 axles. There are three periods with 4-bar application, shown as 0.45@20(1), 0.45@16, and 0.45@20(2), which represent variations in application rate over time. The application rate for the 2-bar period is 0.45@20.

Data suggests that southbound trains show the same reduction from dry (no TOR) and little variation in curving forces during periods when TOR was active, regardless if the

applicators were set for 2 or 4 bars. Northbound trains show little benefit from TOR, regardless if the application configuration was 2 or 4 bars.

Rail Wear

Rail wear data was collected periodically for over 3-years using MiniProf™. For each of the two periods with variable bars — 4 applicator bars (84-128 MGT), and 2 applicator bars (142-184 MGT) — three sets of profiles were collected at approximately 22 MGT intervals. Detailed analysis of the rail removed by grinding (128-142 MGT) is reported in reference 3. At each location, the current profile was compared to the initial data to compute wear rates for each of the two zones. Average vertical wear rates (high and low rails) for all TOR control zone curves for each period are shown in Figure 3. Average high rail GF wear rates are presented in Figure 4.

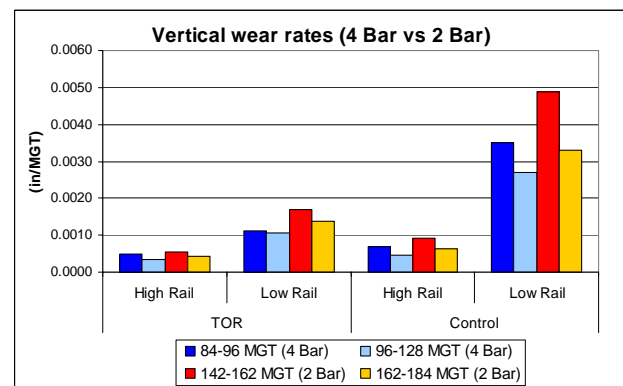


Figure 3. Vertical Wear Rates for Both Zones, All Curves

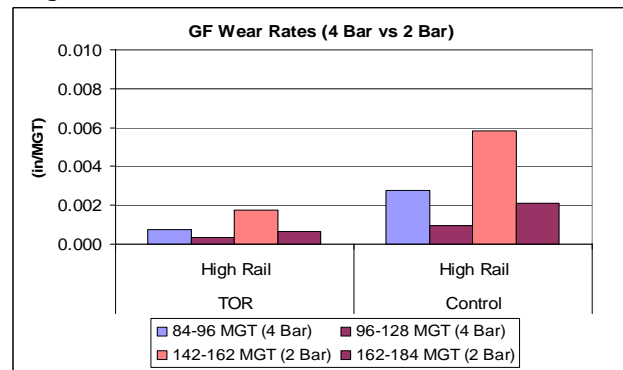


Figure 4. Gage Face Wear Rates, Both Zones during 4- and 2-Bar Application Configurations

Data shown in Figures 3 and 4 indicates the following:

- GF wear rates were higher immediately after grinding in both the TOR or control zones (Figure 4). GF wear rates increased significantly in the control (no TOR applicator) zone than where both TOR and GF lubrication were applied. This also coincided with implementing 2-bar TOR systems in the TOR zone, although no change in lubricating policy was mandated in either zone.
- GF wear rates were higher immediately after grinding in both TOR and control zones (Figure 4)
- The control zone (no TOR) had higher GF wear rates.

- GF Wear rates returned to nearly the same as the previous 4-bar period during the next 2-bar measurement period (162-184 MGT).
- Low rail vertical wear rates increased by a greater amount in the control zone, immediately after the grinding period. This happened even though no TOR lubrication was applied during any period in the control zone.

This data suggests that TOR friction control in Zone 1 and GF lubrication in both zones during the 4-bar period was somewhat better. This may have been due to one or more of the following:

- Slight contamination of GF lubricant to the TOR reducing vertical (TOR) wear.
- Reduced lubrication effectiveness after the grinding period (thus less TOR contamination, resulting in an overall increase in wear rate)
- Reduced TOR friction control immediately after the grinding period.

Records indicate that during midsummer (142-162 MGT period), delays in replenishing the friction modifier inventory resulted in a brief shutdown (approximately 1 week) of the TOR applicators. Also, the reinstallation and adjustment of the GF and TOR applicators may not have been entirely completed at the 142 MGT timeframe when post-grind measurements were initiated. These factors would have an effect on the increased wear observed during the initial post-grind period, which is greater in the control zone. This suggests the importance and need for proper, reliable and continuous GFL and TORFC for controlling rail wear.

RAIL FATIGUE/SURFACE PERFORMANCE

Results published in TD-07-039 indicate that TOR friction control reduces rolling contact fatigue (RCF) and improves overall rail surface performance.³ Dye penetrant techniques were used for this inspection. Results confirm that in Zone 1, with TOR friction control, the rail surface exhibited reduced RCF on high and low rails for each of the seven curves monitored when compared to similar curves in Zone 2.

Visual appearance of rail surface conditions on all curves for each zone show virtually identical trends as during previous inspections. Visual appearance was identical to that described in TD-07-039.³ With the exception of one curve in the control zone (GF only zone, curve U, where the low rail exhibited less RCF and surface damage than low rails in the TOR zone), rails in the TOR zone continue to show less RCF and better surface conditions than rail in areas where TOR friction control is not applied. As with rail wear, RCF performance on individual curves varied somewhat within each zone.

SUMMARY AND DISCUSSION

This site produced measurable results for curving forces, rail wear, and rail surface performance indicating significant benefits when TOR friction control systems were activated.

Recent findings suggest:

- TOR lubricant applied with 2 or 4 bar systems produced similar benefits, provided the same amount of TOR lubricant was applied
- GF lubrication must be maintained to control GF wear

Results are based on maintaining the same overall GF lubrication over both the control and TOR zones. Limited operations resulted in increased rates of wear when insufficient TOR and/or GF lubricant was applied.

FUTURE PLANS AND RECOMMENDATIONS

In response to the railroads, a number of efforts have addressed the need to reduce costs and optimize TOR friction control. This has included optimization of applicator spacing and output rates as reported in TD-05-032 and TD-06-002.^{4,5} An ongoing effort is investigating performance of lower cost TOR friction control materials to reduce cost of the consumables used in this technology. A report on this effort will be available soon.

Results of rail wear rates will be incorporated into a revised cost benefit analysis being conducted on wayside application of friction control. During the past 3 years/200 MGT, the control zone has never been exposed to direct TOR application. Consideration is being given to implant wayside TOR friction control systems over the remaining 15 miles of the Tehachapi grade, which would include the current control zone curves.

ACKNOWLEDGMENTS

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