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Preliminary Implementation Issues for Wayside-Based Top of Rail Friction Control Application Systems

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SUMMARY

Two wayside based top of rail (TOR) application systems spaced up to 1 mile apart on a revenue service line demonstrated effective TOR friction control. Curving forces generated by loaded cars on a 10-degree curve located between two wayside TOR friction control applicators were reduced by 25 to 50 percent, depending on location in the curve (entry or exit) and high or low rail.

The demonstration site was located on the Burlington Northern Santa Fe (BNSF) Keddie to Beiber, California, line. The site features continuous back-to-back curves ranging from 5 to 10 degrees, with mixed freight traffic operating at approximately 13 mph.

Results are based on observations and lateral load data collected over 6 months. A baseline period monitoring the existing condition was followed by installing two wayside TOR applicators at a spacing of 1,900 feet. After monitoring the site for approximately 2 months, the applicators were relocated to a spacing of 3,900 feet and finally to a spacing of 5,500 feet. During each 6-8 week period, curving forces and rail surface conditions, rail profiles, and rail friction were monitored. Additional spacing distances were planned; however, rescheduling of a rail and tie replacement program prevented additional monitoring.

The following describes the results and observations from 6 months of monitoring:

- Absolute reduction in curving forces vary with location in the curve:
 - Reductions ranged from 25 percent to over 50 percent at the 5,500-foot spacing.
- Changes in reduced curving forces with applicator spacing between 1,900 and 5,500 feet were minor:
 - Generally, less than 10 percent with increased spacing.
 - Suggests maximum effective applicator spacing was not yet achieved.
- The effect of TOR friction control on rail surface fatigue, if any, is not clear from the short-term test.
- Applicator system reliability is essential:
 - One system failure was immediately noted by curving forces returning to nearly baseline levels.
 - Once repaired, curving forces were reduced back to normal steady state values.
- To accelerate obtaining steady state conditions, the top of rail between applicators was manually coated with a thin layer of friction modifier at the start of each monitoring period, thus reductions in curving forces were noticed immediately for each location.
- The test site has worn rail and conformal profiles. The carry distance and rail surface fatigue results are based on these conditions.

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Suggested Distribution:

- Maintenance-of-Way
- Track Maintenance
- Mechanical
- Planning & Analysis



INTRODUCTION AND CONCLUSIONS

Controlling rail/wheel friction using locomotive, hi-rail, or wayside-based friction modifier application systems reduces curving forces and train energy.¹ While most early work in the area of top of rail (TOR) friction control was aimed at locomotive-based applicators, recent experience suggests that a wayside based scenario can provide significant, localized savings.

Though locomotive-based systems offer the capability of controlling friction system-wide on all tracks, to be effective, applicators must be properly adjusted, and a large percentage of the road going locomotive fleet must be equipped to ensure adequate coverage. Wayside applicators have been proposed as a means of providing a site-specific solution where a railroad might have a limited territory of severe curves needing friction control.

A preliminary demonstration conducted in 1999 at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center, Pueblo, Colorado, suggested that wayside applied TOR friction control was viable and could carry at least a mile from the applicator.² No train handling or braking issues were noted in these tests. However, the closed loop nature of FAST utilizing a single train repeatedly operating over the same applicator made it impossible to determine implementation guidelines and spacing issues.

FIELD DEMONSTRATIONS

Currently three wayside based TOR friction control demonstrations are being monitored through the cooperation of the Association of American Railroads (AAR) member railroads. These include sites on Canadian National, Union Pacific, and the recently concluded BNSF site near Keddie, California, summarized in this report. BNSF funded the demonstration with supporting data analysis, reporting, and site inspection efforts funded by the AAR.

The BNSF demonstration was configured to address carry distance effectiveness by monitoring curving forces at a central, fixed location, while wayside applicator spacing was increased. The site BNSF provided was between MP 197 and 199 near Keddie on the service line depicted in Figure 1. BNSF installed a truck performance detection (TPD) system on 10-degree curves 198A and 198B; however, the strain gages in curve 198B did not function properly, thus data in this report will be limited to describing performance at curve 198A (cribs 1 and 2). Crib 1 was located at the east end (point of spiral to curve) of curve 198A, while crib 2 was located at the west end of curve 198A, again at the point of spiral to curve.

DATA AND TEST CONDUCT

The TPD installed in November 2002 captured curving forces applied by trains under the baseline and subsequent conditions. During the test period, there was one operating wayside flange lubricator at MP 199.9;

another one located at MP 197.9 remained inoperative during most of the test period.

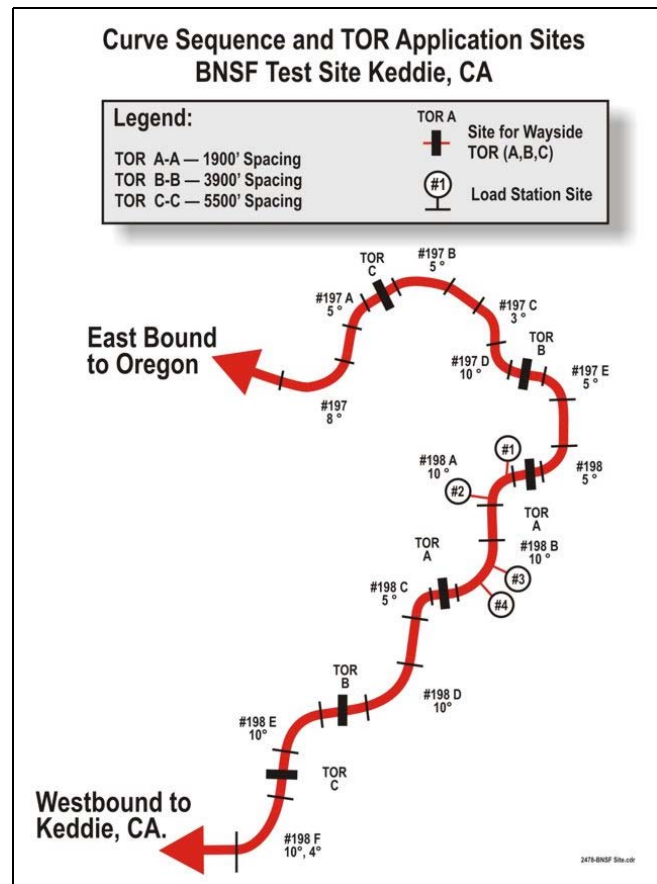


Figure 1. Track Layout and Wayside TOR Applicator Sites

No unit trains operate in this area; therefore, using average curving loads for a given train would not provide a true measure of performance. To interpret load station data, TPCI engineering staff developed software that sorted curving forces produced by each train into three groups, based on average car wheel load: light cars (<12,000 lbs), medium cars (12,000-25,000 lbs), and heavy cars (>25,000 lbs).

Figure 2 shows the time history plot of the average low rail curving forces for loaded cars produced by westbound trains passing Crib 1. Vertical lines designate major changes during the evaluation. These include:

- Baseline: from start until 2-13-03
- Applicator spacing 1900 feet: 2-13-03 – 3-26-03
- Applicator malfunction: 3-26-03 – 4-10-03
- Applicator spacing 3900 feet: 4-10-03 – 5-14-03
- Applicator spacing 5500 feet: 5-14-03 – 6-18-03
 - 5-14-03 – 6-3-03 normal output rate
 - 6-3-03 – 6-18-03 25% increased output

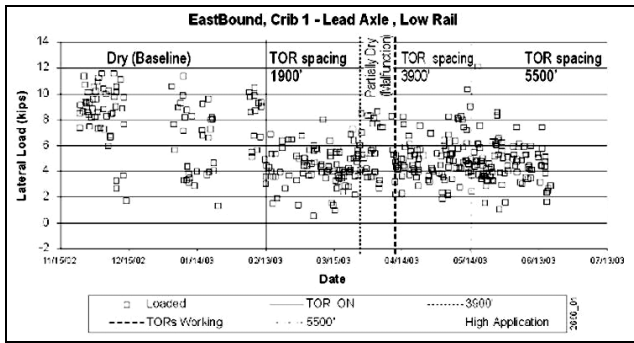


Figure 2. Crib 1-Time History of Average Curving Forces for Eastbound Trains, Loaded Cars, Lead Axle, Low Rail

Loaded cars are made up from a variety of trains, car types and lading, (e.g., lumber, tank, and center beam). Thus, some data scatter is to be expected. By summarizing the average curving force for loaded cars during each period, the effect of different TOR friction patterns and applicator placement becomes more apparent. Figure 3 shows both high and low rail performance for eastbound trains at crib 1. Figure 4 shows westbound train performance at the same crib.

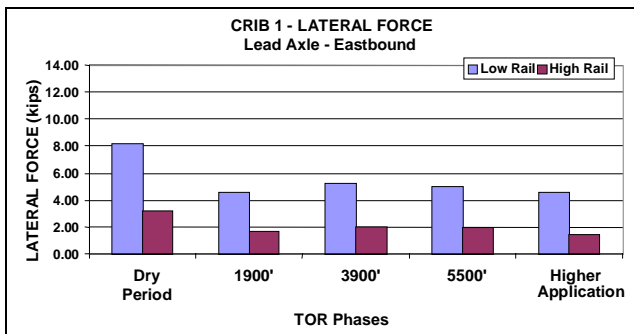


Figure 3. Crib 1-Average Loaded Car Lead Axle Curving Forces during Each Test Configuration, Eastbound Trains

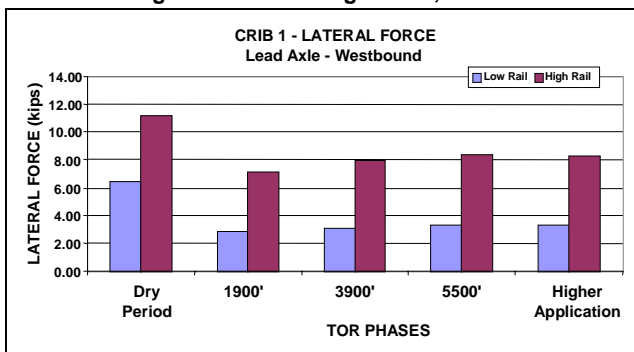


Figure 4. Crib 1-Average Lead Axle Loaded Car Curving Forces during Each Test Configuration, Westbound Trains

The reversal in lateral load pattern between east and westbound trains is likely due to curving effects. Westbound trains passing crib 1 are exiting the spiral and have not yet started constant curving. Eastbound trains have traveled the entire length of the curve and are essentially in steady-state curving when passing crib 1.

Future tests will include additional correlation of effectiveness with respect to distance, central angle, curvature, and length of curves.

Regardless of train direction, however, the effect of controlling TOR friction is seen as reduced curving forces when compared to the baseline period.

INSTALLATION

After the initial baseline-monitoring period was complete, wayside TOR friction control applicators were installed at locations designated by “A” (Figure 1). Portec Protector IV solar powered applicators and TOR applicator bars were installed on the track, as Figure 5 shows. The reservoir was then filled with Kelsan Wayside TOR Friction Control Product, which is designed to produce a 0.3μ coefficient of friction on the rail. For each subsequent separation distance, the pumps, reservoirs, applicator bars, and solar panels were removed and relocated to the revised spacing.



Figure 5. Wayside TOR Application System, Solar Panel and Applicator Bars

Due to the short periods of time allowed for monitoring each spacing, the rail between applicators was primed to jump start the application process. Immediately after the wayside applicator was installed and activated—but before the first train—the rail was coated with the friction control product. Once the thin coating was manually applied onto the TOR, all friction control was maintained by the wayside units.

During the move from a spacing of 1,900 to 3,900 feet, a sensor or control system on one application system became inoperative (between 3/26/03 and 4/10/03). Examining Figure 2 shows that curving forces increased during this period, indicating lack of sufficient friction control product to coat the rail. After replacing the wheel sensor and control system on one applicator, the forces exhibited reduced levels to nearly that of the earlier period. During this period, no train handling issues were reported or raised by BNSF transportation department crews.

RAIL SURFACE FATIGUE ISSUES

Rail surface fatigue is a concern where the rail surface kept flooded with a liquid, such as near lubrication applicator sites. Detailed rail inspection of rail surface conditions was conducted during February 2003 at and near proposed TOR applicator sites and during subsequent visits.

Figure 6 shows the appearance of the low rail of curve 198A, immediately after a rail grinding train passed in February 2003 and just prior to installing the first wayside TOR units. Note the grinding marks on the field and gage side of the rail and the continuous longitudinal surface cracking present in the rail center. The cracks were enhanced by using a dye penetrant. Such cracking was present in the low rail of all curves inspected between MP 197 and 199. Worth emphasizing is that these cracks were present before any TOR friction control application.

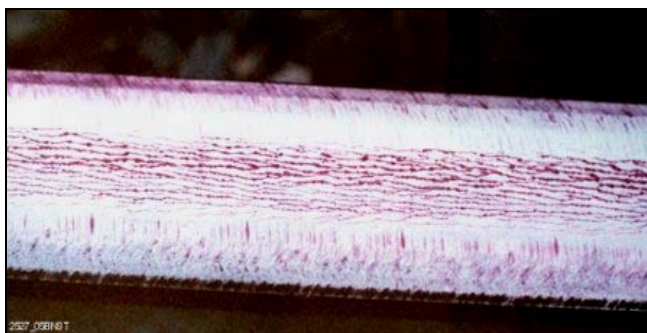


Figure 6. Top of Low Rail, Curve 198A before Implementation of Wayside TOR

Figure 7 shows the same general site (low rail of curve 198A) in June 2003, after approximately 5 months of wayside TOR friction control application. All curves in the 5,500-foot distance between sites C-C were inspected, and only this single curve exhibited such spalling. This spalling was sporadic, generally over distances less than 6 feet at 40 to 60 foot cycles, often associated with nearby welds. Adjacent curves exhibiting the identical longitudinal cracking as curve 198A did not show any signs of spalling or accelerated cracking after the same period exposed to wayside TOR friction control.

Both curves 198A and 198B were the closest to operating wayside units only during the first 6 weeks of operation. As applicators were moved apart, the distance for the friction control material to travel to both curves increased considerably. It is unlikely that moisture or water from the friction modifier carrier was deposited at or near the cracks or directly caused the spalling. The two curves had different head hardened rails, although both curves exhibited nearly identical longitudinal cracking. One theory suggests that the use of TOR friction control alters truck steering such that wheel/rail contact

patterns are changed to produce a different load path, possibly accelerating spalling. It is not clear as to why only one curve developed spalling. Consequently, metallurgical evaluation of samples removed from track is planned.



Figure 7. Top of Low Rail, Curve 198A at End of Test after 5 Months near Wayside TOR Applicators

CONCLUSIONS AND RECOMMENDATIONS

As demonstrated, wayside applied TOR friction modifier suggests reduced forces can be produced by applicators spaced up to one mile apart. Lateral curving forces were reduced 25 percent to over 50 percent. Train crews reported no train handling or braking issues. The need for reliable applicator operation is essential to obtain such benefits. The effect of TOR friction control on rail surface fatigue, if any, is not clear. Additional data on rail profile changes, rail friction, and curving forces will be provided in a full AAR report.

Future work in this area is recommended to determine maximum carry distance/applicator spacing, effectiveness of longer applicator bars, maximum output rate, long-term effects on new rail profiles, and long-term rail fatigue.

REFERENCES

1. Reiff, R. "Locomotive Based Top-of-Rail Friction Control Implementation Results and Issues: Phase 1 - Atomized Spray/Friction Control," May 2003, Federal Railroad Administration, to be published.
2. Reiff, R. and S. Gage. "Evaluation of Three Top of Rail Lubrication Systems, Report R-936, Association of American Railroads, Washington, D.C., December 1999.

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