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Locomotive-Based Top of Rail Friction Control Application Issues Effectiveness and Deployment

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Summary

Locomotive-based top of rail (TOR) friction control was monitored on the Canadian National (CN) Railway near Sahra, Mississippi, in a cooperative effort by Transportation Technology Center, Inc., CN, and The Timken Company. Curving force data was monitored for over a period of 6 months. Only loaded cars and trains with speeds between 15 and 40 mph were included in the monthly averages.

Data from the monitoring period shows TOR equipped trains produced curving forces, on average, 5.5 percent lower than nonequipped trains. Data also suggests that the train following a TOR-equipped train receives little or no benefits. This can be compared to results from evaluating locomotive based TOR systems in a closed loop configuration, which generally produced 30-40 percent reduction in curving forces. Evaluation of maintenance and inspection reports suggests that during much of the performance period, many of the TOR equipped locomotives did not have properly operating TOR friction control application systems, due to a number of reasons including:

- Applicator systems deactivated by train crews. Some crews turned the systems off because they considered them “top of rail lubrication systems” and were concerned about wheel slip.
- Applicator systems out of material.
- Inoperative or failed application system shutting down and not reset by inspection crews.
- Nozzles out of alignment or clogged.

The following trains were used for determining performance:

Non-TOR — Loaded train that did not have a TOR locomotive in the trailing position. Such trains may have had a TOR equipped locomotive, but it was not operational due to position.

TOR — Loaded train with a TOR locomotive in a proper trailing position. The operational status of the TOR system was not known and was assumed to be properly operating.

TOR +1 — First non-TOR equipped train following a TOR train, to determine if any reduction in curving forces was observed from previous end of train residual.

The Association of American Railroads and the Federal Railroad Administration funded this project.



BACKGROUND

Previous tests have shown that top of rail (TOR) friction control provides significant benefits to the rail in the form of reduced rail wear, lower curving forces, reduced train energy, and improved rail surface conditions.^{1,2,3} A special type of lubricant was applied directly to the rail in the early trials of locomotive-based TOR friction control. However, the use of lubricants in TOR applications requires careful control of product quantity to avoid over application and risk of adversely affecting braking or locomotive traction of following trains. Advances and development of friction control materials, instead of lubricants, improved acceptance of the TOR concept. Most TOR friction control application systems currently being deployed are configured as fixed (wayside) or mobile. Mobile systems are usually based on locomotives.

A limitation of wayside application systems is the distance that TOR friction control is effective. Data suggests a TOR application system spacing of 1.5 to 2.5 miles may be needed, depending on severity and density of curves, grade, and other parameters.⁴ Mobile system concepts have an advantage of applying TOR friction control materials over the entire route of train operation, eliminating a need for wayside applicators at frequent intervals.

Limited demonstrations of locomotive-based TOR have shown significant benefits in the form of reduced curving forces and energy savings.⁵ However, for locomotive TOR friction control to be effective, the system must be applying from the trailing locomotive in the consist to avoid possible buildup of fresh material on traction producing wheels. Data suggests that railroads may need to install TOR application systems on virtually all locomotives, or ensure that a TOR equipped locomotive is positioned in the trailing position of multiple locomotive consists. Traction limitations and wheel slip potential may be an issue from carryover of excess friction control material from the end of a train applying TOR to following trains. Data from this demonstration suggests limited or no benefits from one TOR equipped train operating in a route to the next following nonequipped train.

OBJECTIVE

Testing was performed to monitor implementation, deployment issues, and benefits attributable to locomotive-based TOR application systems. Issues addressed included:

- End of train material carryover and benefit to following nonequipped trains
- Percentage of fleet that must be equipped with TOR systems to obtain system-wide benefits
- Deployment issues related to maintenance and upkeep

PROJECT APPROACH AND TEST DATA

For this demonstration, a cooperative effort was conducted by CN and The Timken Company to monitor deployment of 20 locomotives equipped with TrackGlide® TOR friction control application systems. No specific test trains or special runs were operated, thus energy savings were not monitored during

this project. Instead, the effect of TOR friction control on curving forces collected by a wayside based detection system was utilized. This system was installed on a 4-degree curve near Sahra, Mississippi, approximately 44 miles south of Memphis, Tennessee, on the CN (former IC) Memphis-New Orleans main line.

Curving force data was collected for every passing train and sorted by direction, load, and speed. Train identification systems provided information on which trains had locomotives equipped with TOR application systems.

As most traffic was mixed freight and/or intermodal equipment, no two trains with identical makeup were known to have been operated during the monitoring period. Trend data using monthly averages was used to determine if TOR equipped trains produced lower curving forces than nonequipped trains. Initially only a few of the planned 20 locomotives were equipped with TOR systems, and only a few trains each week were TOR equipped. An automated car identification system was installed to facilitate identifying trains equipped with TOR systems. To account for seasonal changes and changes in general track lubrication from a nearby wayside gage face lubricator, curving forces were summarized each month.

LOCOMOTIVE CONFIGURATION

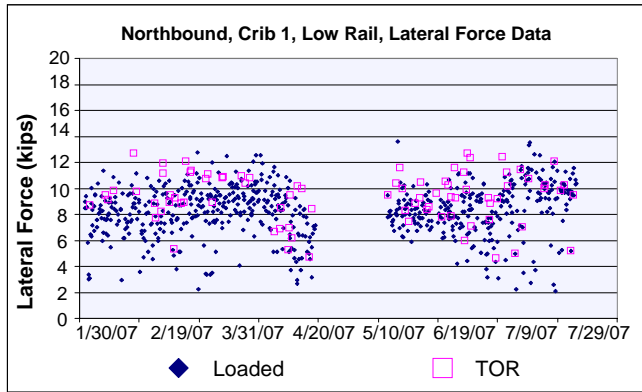
The applicator system was similar in configuration to those installed on previous locomotive-based tests monitored at the Transportation Technology Center, CSX and NS.^{6,7,8} A key issue, however, is that if a locomotive was not in the trailing position, the TOR system was automatically deactivated. Thus even though many trains with equipped locomotives passed the site, over 50 percent of the time the correct locomotive was not in the trailing position, thus not applying TOR friction control material.

RESULTS - Wayside Data (curving forces)

Curving forces for each lead axle of every car in the train were averaged for each train. Figure 1 shows data for each train passing the site over the monitoring period. For this analysis, only loaded cars (>200,000 lbs weight on rail) were utilized. Trains with a TOR equipped locomotive in the trailing position are designated with a box. The data collection system was out of order for 1 month around mid-May.

Data in Figure 1 shows the wide range of curving performance. During the monitoring period, some of the TOR equipped trains produced very low curving forces, suggesting TOR friction control application systems were operational and producing benefits, as seen by improved curving forces. However, some TOR trains produced some of the highest curving forces, suggesting these trains either had inoperative or improperly operating TOR systems, or consisted of truck types that inherently had poor curving characteristics. Some nonequipped trains also produced either very high or very low lateral curving forces.

Grouping average curving forces by month (Figure 2) shows long-term trends and effectiveness of TOR.



Squares show trains with TOR equipped locomotive in correct position.
Figure 1: Curving Forces for Every Loaded Train Meeting Speed and Weight Screening Criteria Passing Test Location

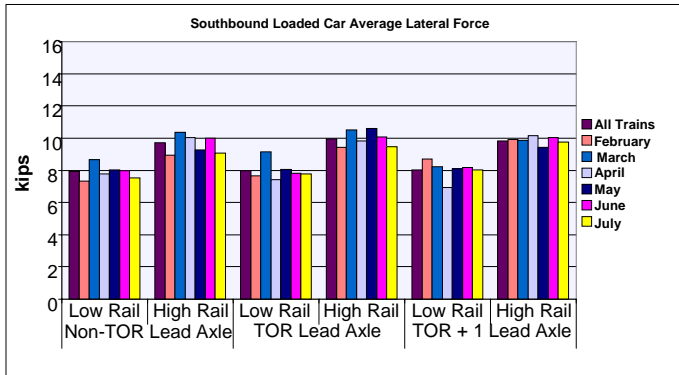


Figure 2: Curving Forces, Southbound Trains Monthly Averages

Data in Figure 2 is grouped into the following major categories:

Non-TOR – Loaded trains that did not have a TOR locomotive in the trailing position. Such trains may have had a TOR equipped locomotive, but it was not operational due to position.

TOR – Loaded trains with a TOR locomotive in a proper trailing position. The operational status of the TOR system was not known and was assumed to be properly operating.

TOR +1 – First non-TOR equipped train following a TOR train to determine if any reduction in curving forces was observed from previous end of train residual.

Monthly data for non-TOR equipped trains shows some variation, thus the average forces produced by any one group will also likely vary. To compensate for this variation, train performance for the three categories is compared within the same month. Table 1 summarizes curving performance during April and June, and for the entire monitoring period.

Table 1: Curving Forces Generated during April, June, and Entire Monitoring Period (Data shown is kips of average lateral curving forces.)

Train Type/Period	April Low Rail	June Low Rail	Full Period Low Rail	April High Rail	June High Rail	Full Period High Rail
Non-TOR	7.79	7.94	8.14	11.78	12.44	12.19
TOR	6.03	7.79	7.77	10.57	11.38	11.49
TOR % Benefit vs. Non-TOR	-22%	-2%	-5%	-10%	-9%	-6%
TOR+1	7.19	7.70	8.19	11.17	12.54	12.23

Data suggests that during April, both the high and low rails benefited by reduced curving forces from TOR trains, with the low rail showing a 22 percent reduction. Some benefit was also seen by the TOR+1 trains. Performance during the full period (June shown as typical) suggests TOR trains produced curving forces only slightly lower for both low and high rails, in the range of 5 percent to 6 percent. This should be compared to TOR friction control as applied by wayside systems, which typically produce reductions of 30 percent to 40 percent.⁹

Based on feedback from railroad and supplier personnel involved in inspecting the TOR systems, the small reduction in curving forces from TOR equipped trains is likely due to fewer than the desired number of properly operating systems. Over the period, a number of reasons were noted. For example:

- Damaged applicator nozzles from high turntable ramps. This was addressed early in the program.
- Applicator systems deactivated by train crews. Some crews turned systems off, as they considered them “top of rail lubrication systems” and were concerned about wheel slip. Control systems have been rewired to limit this activity.
- Applicator systems out of material.
- Inoperative or failed application system shutting down and not reset by inspection crews.
- Nozzles out of alignment or clogged.
- Application rates may have been too low.

During April 2007, a special effort was made by management and supplier forces to ensure all equipped locomotives were properly operating and not being turned off. Results of this effort, as seen in the April data, suggest a significant improvement in performance was obtained, but only during that timeframe.

No energy measurements were conducted during this demonstration. An evaluation using the same TOR concept, where operational status of TOR was confirmed, produced over the road energy savings of 7.8 percent.⁷ This condition

corresponds to curving force reductions produced in closed loop tests at TTC using locomotive based TOR of 30 to 40 percent. TOR trains during April produced about 50 percent of the benefit achieved during other closed loop tests. Actual onboard monitoring would be required to determine actual energy savings over this specific route.

SUMMARY/RECOMMENDATIONS

While data from closed loop and field tests with dedicated test trains shows locomotive based TOR offers significant benefits, results from field monitoring suggest the level of such benefits are not being achieved during routine deployment. Results from monitoring curving forces suggest trains following a TOR equipped train receive little or no benefit, thus under the current application rates and deployment, every train must have an operating application system to obtain full benefits.

Evaluation of curving forces indicated the best performance in reduced curving forces was obtained during April when extra attention was made at inspection and maintenance points. This effort was conducted to ensure TOR systems were properly operating. During this period, low rail curving forces were reduced by 22 percent; however, this should be compared to 30-40 percent reduction typically achieved by closed loop locomotive based testing. During the 6-month monitoring period, some TOR trains generated curving forces that were much lower than the average, indicating that TOR systems were likely active and operating properly. However, several TOR trains also generated curving forces much higher than average, suggesting that the TOR system on those specific trains was not properly functioning, and produced little benefit.

Similar experience was observed by other railroads during earlier (1985-1990) locomotive based lubrication system monitoring efforts. Many locomotive crews routinely shut off applicator systems, incorrectly thinking they were a cause of wheel slip. Crews at servicing locations did not properly inspect or adjust applicator systems and were not given training and sufficient time to conduct these extra tasks.

While additional effort is suggested to optimize application rates and system adjustments, mobile-based TOR friction control application systems mounted on locomotives appear to be susceptible to many of the same issues as earlier locomotive mounted lubrication systems. Railroad management policies must incorporate sufficient training and time to conduct such inspections. Train crews must be educated in not only the value of such systems, but that when properly operating, no adverse effects on train handling will occur.

Field inspection and feedback procedures and methodologies are not in place to detect when a locomotive system is not functioning properly. If field personnel observe incorrectly or inadequately operating systems, a communications protocol is needed to ensure the information is transmitted to the proper area for attention. For example, when a wayside application system is not functioning properly, nearby curves are generally

affected and routine track inspections will detect such conditions. Follow-up adjustment is usually the responsibility of the inspector; however, in the above case with locomotive based applicators, there is no clear path or responsibility for inspection, notification and adjustment.

ACKNOWLEDGEMENTS

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