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Mobile-based Car Mounted Top of Rail Friction Control Application Issues— Effectiveness and Deployment

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Summary

The benefits of operating a mobile-based top of rail (TOR) friction control system were demonstrated on a revenue service route through the cooperative efforts of the Association of American Railroads, Federal Railroad Administration, Union Pacific Railroad, and Kelsan Technologies. A car-mounted TOR friction control system offers potential advantages over conventional wayside-based TOR friction control systems, because friction control material can be applied over an entire route by one system. In addition, remote control of the application systems accessed by radio links offer the ability to change application rates without the need for field access.

Effectiveness of the TOR friction control system was determined over the entire 500+ mile route by measuring energy on board the train and by monitoring lateral curving forces in a 4-degree curve at a single, specific location.

Results suggest that while there were benefits for the entire route, at specific locations (such as the one selected for monitoring curving forces) some benefits are marginal.

Energy savings, measured by electrical power produced by locomotives, for the TOR friction control equipped trains over the entire route from Wyoming to Kansas were approximately 4.9 percent, while savings on a selected low gradient segment were 12.5 percent.

Average curving forces over 6 months for TOR friction control equipped and nonequipped trains showed no significant differences. Only a limited number of cars at the front of the trains realized significant reductions in curving forces on the TOR friction control equipped trains. For these trains, no benefit was seen after the first 100 axles.

Additional effort is needed to optimize friction control application rates and TOR friction control system adjustments to ensure the entire route is receiving the optimum amount of TOR friction control material (e.g., adjust spray patterns at speeds >45 mph). In addition, reliability and effectiveness of the TOR friction system need further improvement. Crews need to be trained to ensure that the TOR friction control applicator car is properly positioned in the train and that power leads are hooked up to enable TOR friction control system operation.



INTRODUCTION

Top of rail (TOR) friction control provides significant benefits in the form of reduced rail wear, lower curving forces, reduced train energy, and improved rail surface conditions.^{1,2,3,4} TOR friction control systems utilize a variety of wayside and mobile-based application systems and have been demonstrated in closed loop and field sites. Most current field demonstrations have utilized wayside-based (fixed location) application systems for a number of reasons:

- Wayside-based TOR friction control applicators have undergone the most development in recent years.
- Controlled rail wear and other monitoring can be conducted over manageable (short) distances. This allows effectiveness to be controlled and monitored using three to eight TOR application systems.

These demonstrations followed similar methods of monitoring rail wear and curving forces for a period of time. By pro-rating results, this data has been used to show benefits of implementing TOR friction control over a wider territory. Because these wayside demonstration sites have been over short distances, there has been no attempt to measure energy savings.

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

OBJECTIVE

This research project monitored TOR friction control implementation and deployment issues and documented benefits that can be achieved from a mobile-based TOR friction control application system. For this project, a hopper car was the platform for the TOR friction control applicator. Installing a mobile system on a revenue car instead of a locomotive may result in fewer systems required to cover a given route.

Project Approach and Test Data

This evaluation utilized only two mobile-based TOR friction control systems, thus the long-term effects of having more TOR friction control equipped trains mixed with a large number of nonequipped trains on rail could not be evaluated. TOR friction control effectiveness was determined by monitoring electrical energy produced by locomotives over the route and by using load station data configured to measure lateral curving forces installed on a 4-degree curve near Lawrence, Kansas. Changes in curving performance of trains equipped with a mobile-based TOR system were compared to similar nonequipped trains. Energy consumed for similar TOR friction control equipped trains and nonequipped trains was summarized over selected route segments. Wayside forces provided a check on the benefits of the mobile-based TOR friction control systems at one track location, while onboard

data provided an indication of benefits of the mobile-based TOR friction control systems over the entire route.

Applicator Configuration

The applicator systems (Figure 1) were similar in configuration to the prototype ore car-based TOR friction control applicator utilized on the Quebec Cartier Mining Railroad demonstrations conducted in December 2004.¹ Specific details vary from the prototype due to host car design, but the basic components are similar:

- Electrical power supplied from the locomotive multiunit (MU) connections
- Onboard global positioning system (GPS) based control system
- Air supply from the locomotive main reservoir
- Onboard friction control material reservoir (for this test, Kelsan Freight TOR Material)
- Applicator nozzles mounted to the car truck frame apply friction control material directly to the top of rail

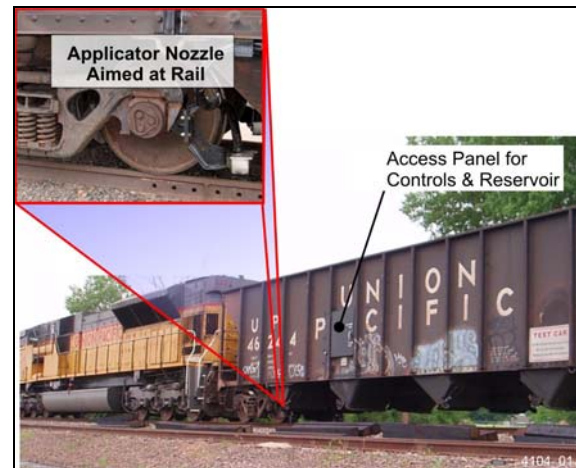


Figure 1. Photo of TOR Friction Control Applicator Car and Nozzle System

A GPS-based map is programmed into the operating memory of the TOR friction control system for the specific operating route. This information, along with preprogrammed information on curvature, grades, and other route data, is used to adjust TOR friction control output for various track segments, curves, and other operating restrictions. These instructions are based on information regarding TOR friction control needs, individual railroad restrictions or requirements (e.g., ceasing TOR friction control application during braking and below speeds of 10 mph). The current configuration requires that the TOR friction control car be operated as the first car in the train to obtain electrical power and air, as well as to apply friction control material behind the locomotives.

The TOR friction control application rates programmed for this demonstration were designed for a coal route. GPS information allowed the system to determine if the train was moving from the mine towards the power plant (loaded) or from the unloading facility to the mine (empty), and adjusted friction control output rates as needed for heavier or lighter wheel loads.

RESULTS

Load Station Data (curving forces)

Curving forces for each axle of every car in the train can be used to show within-train performance, as well as full-train average performance. As carbody and truck styles have a significant influence on curving forces, only trains with nearly identical equipment were compared for this evaluation. Figure 2 shows the curving forces generated throughout the train (front to rear) of a typical nonequipped train and a typical TOR friction control equipped train.

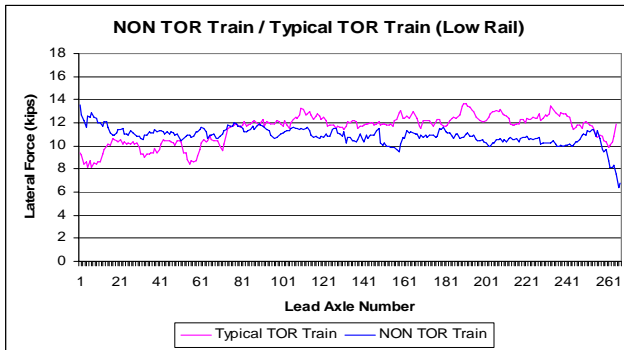


Figure 2. Low Rail Curving Forces, Front to Rear for TOR Friction Control Equipped and Nonequipped Trains

Data in Figure 2 suggests the mobile-based TOR friction control system was effective in reducing curving forces for the front three to forty cars (up to lead axle 80) of the 130-car trains, immediately behind the TOR friction control applicator car. However, the friction control material application rate utilized during this period of testing appears to be insufficient to reduce curving forces throughout the entire train. The drop in lateral curving forces near the end of both trains is attributed to the use of rear-pusher locomotives.

The train passed the measurement site at operating speeds ranging from 20 mph to 30 mph, and during the program seasonal differences along with changes in gage face lubrication influenced the overall curving performance for all trains. Figure 3 shows the average curving forces generated for nonequipped trains for speed ranges in 5-mph increments. As can be seen, there are variations month to month for each speed range.

Figure 4 shows average curving forces for all trains for each incremental speed range, separated by TOR friction control equipped and nonequipped trains.

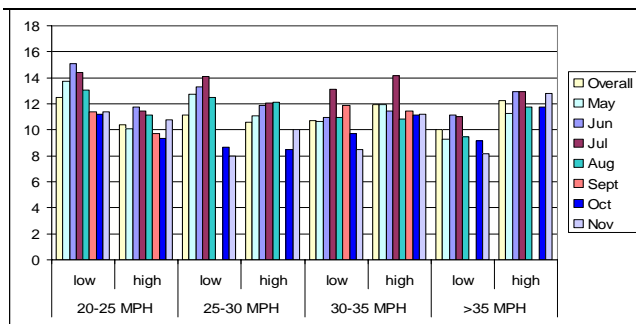


Figure 3. Monthly Average Curving Forces – Nonequipped Trains

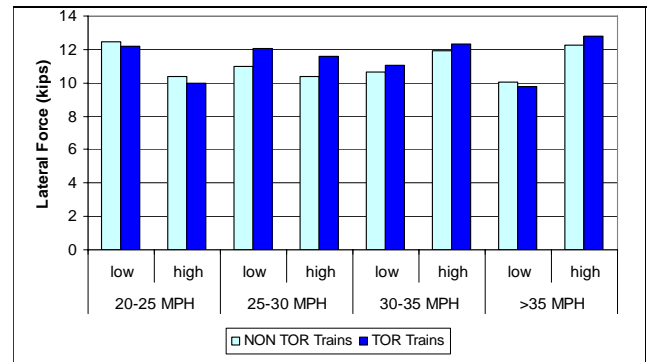


Figure 4. Period Average Curving Forces for Nonequipped and TOR Friction Control Equipped Trains, Grouped by Incremental Speed Ranges

Data in Figure 4 suggests that TOR friction control equipped and nonequipped trains produced about the same average curving forces. Only a few isolated trains exhibited the front to rear differential pattern shown in Figure 2 during the monitoring period. Few (<4) TOR friction control equipped trains passed the load station per month, as compared to about 25 nonequipped trains. While more runs per month with TOR friction control equipped trains were made, the number of valid TOR friction control equipped runs was limited due to several factors:

- Trains stopped, then restarted 3 to 5 miles prior to the load station, wiping friction control material from the wheels
- Inoperative or failed TOR friction control application system shutting down near the measurement site
- Trains operated on adjacent 2nd mainline track
- Slow orders, trains stopped over the measurement site due to congestion
- Trains rerouted due to area flooding
- TOR friction control car MU connections inadvertently disconnected or car switched to nonlead position in the train

Other issues that may have caused insufficient TOR friction control material to be applied to and/or reaching the rail include:

- Friction control application rates may have been too low
- Wind or air turbulence at higher operating speeds preventing proper TOR friction control material transfer to the wheels and rails

These last two items were addressed with additional runs using higher friction control application rates and with the use of air deflection baffles placed on the TOR friction control car. However, because of project budget limits, additional data collection could not be performed. During the 6 months of monitoring, no train operating or train braking issues were reported related to low values of TOR friction.

Energy Summary

Onboard train energy was collected by UP. Several route segments of 60 miles to 100 miles were selected where normal operations allowed near steady-state running. Energy consumed by train passage through each of these segments was averaged for many runs. Tables 1 and 2 show summaries for nonequipped and TOR friction control equipped trains.

Table 1. Energy Summary through Least Grade Segment

Loaded Trains – Least Grade Segment			
	Count	Average Tons	Gal/1,000 GTM
TOR friction control equipped Trains	12	19,235.42	0.182
Nonequipped Trains	83	18,567.34	0.208
Difference		3.60%	-12.48%

Table 2. Energy Summary through All Segments

Loaded Trains – All Segments			
	Count	Average Tons	Gal/1,000 GTM
TOR friction control equipped Trains	52	19,179.58	0.359
Nonequipped Trains	353	18,643.96	0.378
Difference		2.87%	-4.86%

Tables 1 and 2 also show while TOR friction control equipped trains were heavier than the nonequipped trains by approximately 3 percent, the TOR friction control equipped trains required less energy to move. For the route with the least gradient, the reduction in energy to move TOR friction control equipped trains was about 12.5 percent, but for all segments it was about 4.9 percent. This confirms that energy savings are highly route and train operations dependent. More detailed information on curvature, gradient, and train speed effects is needed to allow modeling predictions of energy savings over a specific route. In this comparison, there are a lot more nonequipped trains than TOR friction control equipped trains, because there were only two TOR friction control applicator cars available for the test and they were not always operating properly.

SUMMARY/RECOMMENDATIONS

Evaluation of curving forces indicates that only a limited number of cars at the front of the trains realized significant reductions in curving forces on the TOR friction control equipped trains. For these trains, the benefit was not seen after

the first 100 axles. Average curving forces over 6 months for TOR friction control equipped and nonequipped trains did not indicate any significant difference. Energy savings for the TOR friction control equipped trains over the entire route from Wyoming to Kansas were approximately 4.9 percent, while savings on a selected low gradient segment were 12.5 percent.

This suggests that while benefits are being achieved for the entire route, at specific locations (such as ones selected for monitoring curving forces) some benefits are marginal. This confirms that additional methods for determining proper operation of TOR friction control systems are needed.

Additional effort is needed to optimize friction control application rates and TOR friction control system adjustments to ensure the entire route is receiving the optimum amount of TOR friction control material. In addition, TOR friction control system reliability and effectiveness need further improvement. Spray patterns for trains that operate at higher speeds (>45 mph) need to be optimized to ensure proper FC material application. Crew training is needed to ensure the TOR friction control applicator car is properly positioned in the train and the power leads are hooked up to enable TOR friction control system operation.

Acknowledgements

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