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Signal Shunting Performance Related to Application of Wayside Based Top of Rail Friction Control Materials

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Summary

The use of Top of Rail (TOR) application systems to control friction is becoming more common, with major benefits seen in lower curving forces, reduced energy consumption to move trains, and improved rail life. Investigation by Transportation Technology Center, Inc, (TTCI), Pueblo, Colorado, of a friction modifier (FM) material specially designed to be applied to the top of the rail from a wayside system suggests that no adverse effects on track signal shunting performance were produced during normal and double application rates or during a period when the applicator rate was increased to eight times the normal rate. This excessive application rate, however, did produce undesirable low friction levels.

Through cooperation of Norfolk Southern, a short (50-foot long) modified grade crossing island track circuit was installed on one track of a double mainline with predominantly westbound empty coal train traffic, which can be susceptible to films or other products on the rail affecting track signal shunting. By monitoring the voltage of this island track circuit, shunting performance of single trucks was determined. A wayside TOR system was located immediately east of the circuit. All westbound trains would first encounter the TOR material before traveling over the track circuit. During the entire test period no continuous loss of shunt was ever observed during any train passage. Due to the intentionally short length of the island track circuit utilized for this test, on rare occasions long cars exhibited short periods of shunt loss as the front truck was departing the island while the rear truck was entering.

Under direction from the Association of American Railroads (AAR) Lubrication Technical Advisory Group and Vehicle Track Systems (VTS) Committees, a number of implementation issues related to potential adverse side effects from TOR systems are being investigated. This is to ensure deployment of the TOR friction control concept, which places FM materials directly on top of the rail, and does not introduce unwanted conditions. These issues include possible adverse reactions affecting routine train braking, tractive effort, sanding, ultrasonic rail flaw inspection signals, and track signal shunting.

Rail friction measurements on the running surface during the excessive application period indicated a drop in friction from 0.55μ to 0.28μ. Also, a dark band of material was noted on the top of the rail after the applicator, confirming that the FM was being deposited on top of the rail. Results suggest that even with moderate to excessive application, the FM material utilized did not adversely effect signal shunting of multiple cars or a full train. Other issues, such as traction and braking, will be investigated in future demonstrations.

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Introduction and Background

Recent investigations and demonstrations of Top of Rail (TOR) friction control systems have shown significant benefits can be obtained in the form of reduced curving forces, reduced rail wear, and reduced energy needed to propel trains. The TOR concept is different than traditional gage face lubrication in that a special material, termed a friction modifier (FM), is applied to the top of the rail rather than the gage face of the rail.

A number of issues regarding TOR systems have been raised by railroads. The objective of the research is to ensure that safety and operating efficiency are not compromised when deploying TOR systems.

Although it is understood that for decades some grease has migrated from the gage to the top of the rail at wayside gage face application systems and occasionally from hi-rail and locomotive-based gage face lubrication application systems, such migration is not intentional and usually occurs at isolated areas.

As TOR systems apply FM materials to the top of the rail, a concern has been raised that the film could build up an insulating layer between the rail and wheel. This condition, should it occur, would inhibit track signal shunting at grade crossings and short detection blocks.

To address this concern, the Transportation Technology Center, Inc. (TTCI) and Norfolk Southern (NS) cooperated in a field demonstration to monitor track signal shunting performance under a variety of TOR conditions.

Limitations of this Demonstration

To limit the cost of this evaluation, performance of what is currently the most commonly utilized wayside based TOR product was evaluated. Results of this simulation are based on the Portec Protector IV application system applying KELTRACK® TOR Freight Friction Modifier. This combination is in use in at least 10 areas by major railroads and represents typical conditions currently being created. A number of other FM products and application systems are also being investigated by railroads including hi-rail and locomotive-based systems; however, as of this date, these have not achieved wide spread implementation. It is suggested that other FM products, especially those with different viscosities, components, and applied thicknesses from that evaluated by this project, be examined in a similar fashion if loss of shunt becomes an issue. Effects of blowing sand or other contamination added to the film was not evaluated.

Track Signal Shunting

The location or presence of most trains is detected by the shorting (shunting) of low voltage track circuits. Shunting occurs when the electrical path from one rail to the other is bridged by one or more wheelsets, resulting in a short circuit. If a film or contaminant insulates part of this path then shunt can be interrupted. This condition is also termed "loss of shunt." With light cars and short consists, this can result in premature release of grade crossing warning systems or in rare cases a complete loss of train location within a controlled block. Sometimes an intermittent shunt will cause crossing gates to bob up and down, confusing motorists. For these reasons a reliable shunt, especially over short grade crossing island circuits (lengths of 120 feet) is essential to maintain safe and reliable train operations.

Test Location

During the past year, NS has implemented 14 wayside-based TOR application systems over a section of double track east of Bluefield, West Virginia. Although each track is capable of and receives bi-directional traffic, most westbound traffic, which consists primarily of empty coal unit trains, is routed on Track 2. Studies have shown* that loss of shunt is more common with light axle loads where films can create a high resistance, or even destroy, the electrical path between the rail and wheel. Figure 1 is a view looking westward of the overall shunt monitoring site and key features.

Figure 1. Signal Shunt Monitoring Site and Key Features

Shunt Monitoring

To determine the effect of TOR FM on shunting, a short track circuit was installed on Track 2 near mile post (MP) N357.9, Figure 2. This short circuit was 50 feet in length and was intended to capture the shunting characteristics of a single car or pair of trucks. The short length of this track circuit is understood to be worst case. A longer circuit would allow more axles to be present, thus reducing the effect, if any, of TOR FM films causing even intermittent loss of shunt.

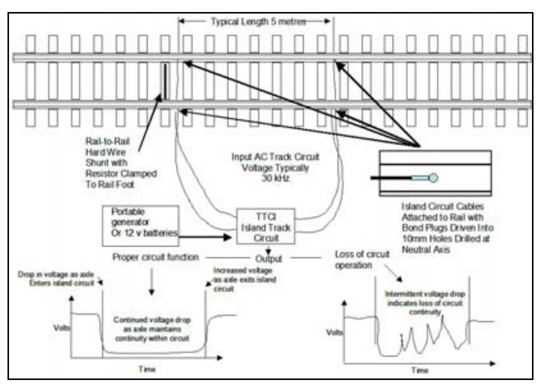

Figure 2: Schematic of Short Track Circuit

* *FRA Report: DOT/FRA/ORD-197/04, Influence of Contact Patch Resistance on Loss of Shunt at Highway/Railroad Grade Crossings.*

The track circuit uses a modified island card with a 20.1 kHz frequency. As installed, the transmitter and receiver wires were spaced 50 feet apart. The island was calibrated using a conventional rail to rail shunt. Variations in ballast resistance throughout the test resulted in island length varying from the installed 50 feet to as much as 54 feet.

The island circuit was active at all times, with the output driving an "island relay." At a conventional crossing, the island relay would be used to control the release of gates and flashing warning lights after train departure.

A data collection system continuously monitored the island receiver voltage and state of the island relay. A magnetic wheel sensor was used to trigger data collection and file saving routines. The island voltage and island relay status of every train passing were recorded.

Results

Data collected over almost 4 months under a variety of conditions did not show any significant loss of shunt, either during baseline (no TOR) or when the TOR system was activated for double normal application rates. Due to track maintenance requirements (rail grinding and tie replacements), the TOR systems were occasionally deactivated (Table 1). TOR operating history with the application rates is shown in Table 1.

Table 1. Pump Setting Operating History

Period	Start	End	Output Gal/1,000 axles
No TOR	2/14/05	3/17/05	Off
Normal TOR	3/17/05	4/14/05	0.045
No TOR	4/14/05	5/04/05	Off
Normal TOR	5/04/05	5/24/05	0.045
2X TOR	5/24/05	6/01/05	0.09
8X TOR	6/02/05	6/06/05	0.36
Normal TOR	6/06/05	6/10/05	0.045

June 2, 2005 through June 6, 2005, a test using eight times (8X) the normal application rate was conducted to flood the rail surface with FM material. During this test, the normal TOR application rate was 0.045 gal/1,000 axles. After completion of this test during August 2005, the normal TOR application rate was increased above the former rate of 0.09 gal/1,000 axles to 0.13 gal/1,000 axles to optimize reduction in curving forces due to train braking issues. This was intended to simulate conditions created by an incorrectly adjusted or malfunctioning pump.

Prior to the start of the 8X application period, the site was inspected and the north rail applicator bars were found to be leaking from the side seals. The bars were tightened to ensure a good seal was made with the rail, then the output rate was increased. The 8X application test rate was only conducted for a short period of time to avoid any traction related problems. TOR friction measurements taken during the 8X application period suggest that excess TOR FM material was being applied. Table 2 shows the following friction values that measured after 24 hours of 8X application.

Table 2. Friction Values after 24 hours (8X)

Location	N Rail	S Rail
50 feet East of Applicator	0.56 µ	0.59 µ
50 feet West of Applicator	0.23 µ	0.26 µ
250 feet West of Applicator	0.36 µ	0.37 µ

Friction data suggests the predominant westbound traffic encountered dry rail just prior to the applicator and was in a heavily contaminated area 50 feet west of the applicator, within the track circuit shunting limits. Visual inspections indicated rail in this area had a thick, dark film, and thus is considered to be a worst case condition for loss of shunt to occur. The rail condition immediately after the applicator had such an appearance that under any normal routine track inspection, the applicator would have been deemed defective and the system adjusted or deactivated.

Island Voltage and Island Relay Data

During the full testing period, hundreds of trains were monitored. Each train history is contained in a single file that can be shown with three plots, as follows: Top plot is the wheel sensor trigger, middle plot is the island relay condition, and bottom plot is the island voltage at receiving end. For the entire monitoring period an occasional train exhibited impending loss of shunt on one or two axles. An example plot from the baseline, no TOR period, is shown in Figure 3. This shows several spikes in the bottom voltage trace and one island relay pickup (middle trace). Such performance was traced to a long car (89-foot flat) which may have been just long enough so that the lead truck was exiting the island before the trailing truck fully entered the island limits. These sporadic, infrequent occurrences were not considered loss of shunt that could affect safety as such short, 50 foot track circuits are not normally used.

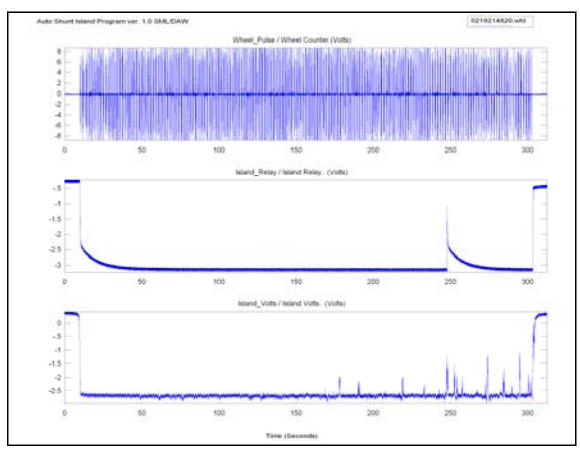

Figure 3: Baseline, No TOR Period. Showing Short Periods of Loss of Shunt Associated with Individual Trucks

Similar sporadic occurrences of island voltage spikes were observed during all periods (no TOR and all TOR rates). In almost all cases these spikes were of too short a duration to affect the island relay. An example of island voltage spikes, but no relay deactivating, is shown in

Figures 4 (during the normal TOR application period). The 8X application rate period produced the thickest film; however, this was not reflected in any significant increase of voltage spike occurrences. Figure 5 shows typical performance during the 8X period, with the island voltage trace exhibiting a smooth signal, indicating no voltage spikes or loss of shunt.

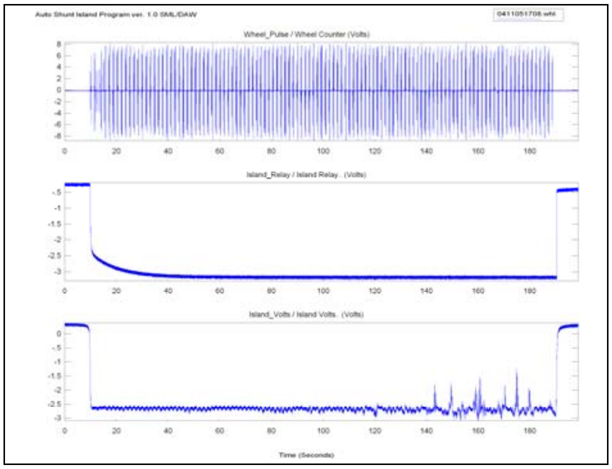

Figure 4. Typical Train During the Normal TOR Application Period Island Voltage and Island Relay Performance

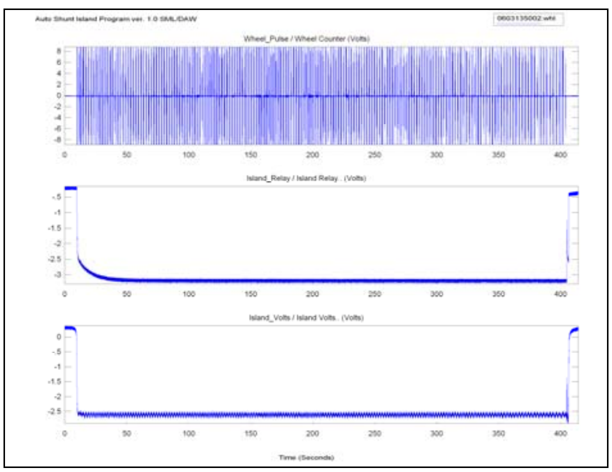

Figure 5. Island Voltage And Island Relay Performance Due To A Typical Train During The 8x Application Period. Note No Voltage Spikes

After 4 days of 8X, the application rate the TOR system was returned to its normal setting. Two days later, two trains exhibited single trucks that momentarily lost shunt in an identical pattern as that shown in Figure 3, suggesting a series of long cars operating over the short island. At no time did two or more trucks continuously lose shunt during the time when the application rate was 8X normal or afterwards.

Conclusions and Recommendations

Data collected for this test period suggests that under even the most over applied FM conditions a train would not lose track signal shunting in a standard length (120-foot) island. Although minor, single axle, or single truck loss of shunt might briefly occur when an excessive amount of FM product is applied to the top of rail, it is likely that adjacent axles would allow completion of alternative electrical paths, producing normal shunt performance.

Friction values produced during the overly excessive 8X application period (generally less than 0.25µ average) and dark rail appearances were such that these would have been spotted by routine track inspection. As the mess and top of rail condition produced under such application rates is undesirable, it is expected that a track inspector would have corrected this situation before it could lead to a train handling situation.

Finally, these evaluations were limited to a 4 month period and were not in an area with wind blown contamination. While some train sanding was conducted in this area, most westbound empty trains did not require the use of sand. The addition of significant contamination could adversely affect shunt.

Other TOR Issues

One issue noted during the beginning of this test was clogging and unequal left/right rail application of the FM material from the applicator. This was from the original short bar design. The current design was improved in terms of this performance. This resulted in one rail with TOR friction level of 0.3µ, and the other rail with a TOR friction level of 0.5µ. These values occurred immediately after the applicator system and were on tangent track. The nearest curve in the westward direction of travel from this particular applicator was several thousand feet away and no adverse conditions were noted.

NUCARS® simulations of freight car curving suggest when the top of the low rail friction is higher than the top of the high rail friction by differences greater than 0.1µ, curving forces will increase.

A future investigation is planned to simulate this condition at a site near rail force measuring equipment. Results will include an assessment of differential friction levels immediately at the TOR applicator and at various distances from the applicator on reverse curves. Along with friction levels, the curving performance on adjacent reverse curves will be evaluated.

Acknowledgements

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