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Applicator Spacing, Application Rate, and Rail/Wheel Profile Issues Affecting Top of Rail Friction Control Effectiveness

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Summary

BNSF Railway (BNSF) conducted a demonstration of wayside-based top of rail (TOR) friction control effectiveness, where results suggested wayside-based applicators could be effective with minimum 3,000 feet spacing. Subsequently, a Phase 2 TOR trial was initiated to determine extended applicator spacing while continuing to apply effective friction levels. The primary goal was to investigate TOR friction control effectiveness with applicators spaced up to 8,550 feet. The Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, participated by evaluating lateral curving forces. BNSF measured rail wear, TOR friction levels, and qualitatively assessed the rail surface condition.

Phase 2 was conducted at the original TOR demonstration location; however, the track structure was extensively rebuilt by BNSF. New, 141-pound rail and concrete ties replaced existing timber ties and worn rail. The track on either side of this location was targeted with wayside-based TOR applicators at increased spacing. During this period, TOR friction control was provide by applying KELTRACK® freight friction modifier, with effectiveness determined by monitoring lateral curving forces on a 10-degree curve.

Average curving force reductions ranging up to 48 percent were observed. The reductions were variable depending on train direction and distance from the TOR applicator. The largest reduction was obtained with an increased, non-typical application rate and closer spacing of 2,700 feet. In comparison, Phase 1 achieved 25 percent to over 50 percent lateral curving force reductions. In addition, Phase 1 lateral curving force results demonstrated little dependence on increasing TOR friction control applicator spacing (1,300 feet to 5,500 feet) and varying TOR friction control application rates.

A major factor differing between the Phase 1 and Phase 2 trials was the new rail installation and resulting operation over the significantly changed rail profile and stiffer track. The new rail profile may have reduced effective carry of the TOR friction control material due to a smaller wheel/rail contact area, higher contact stress, and different wheel contact locations. This also may have led to increased sensitivity to applicator spacing and application rates. Results suggested that when rail is replaced, output rates for optimum TOR friction control effectiveness may need to be adjusted (increased), and expected benefits may be less until the rail/wheel contact region becomes more conformal.

No rolling contact fatigue or other rail surface anomalies developed during the Phase 2 observation period. Future demonstrations of TOR applicators are being conducted under AAR sponsorship and will include performance studies when new rail profiles are introduced.

Introduction and Background

During Phase 1 of this program, BNSF Railway (BNSF), Kelsan, Portec, and the Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, conducted an initial demonstration of wayside-based top of rail (TOR) friction control effectiveness. Results[1] suggested effectiveness of TOR was adequate with applicator spacing of 5,500 feet. Wider applicator spacing however would benefit cost economics of the TOR friction control concept.

After the track in the test area was upgraded with new rail and concrete ties, BNSF elected to continue the monitoring program in order to investigate effectiveness or carry-down with target TOR applicator spacing up to 8,550 feet. As with Phase 1, performance would be determined by monitoring reductions in lateral curving forces. BNSF measured rail wear and provided the loads stations for monitoring curving forces as well as conducted inspections of rail surface conditions, while TTCI collected and analyzed lateral force data.

Site Overview

The site is located in a territory with numerous 10-degree back-to-back curves. Traffic is bi-directional with tonnage 60 percent westbound and 40 percent eastbound. Two 10-degree curves (C-198A and C-198B) were instrumented with strain gages. Crib 1 and Crib 2 were located on C-198A, while Crib 3 and Crib 4 were located on C-198B.

The lateral force analysis for this report focuses on Crib 1 and Crib 2. Figure 1 shows the track chart for this area.

TOR Applicators and Materials

This demonstration utilized two Portec Protector IV® TOR friction control applicator systems with analog control boxes, applying KELTRACK® freight friction modifier (FM). The control system allows application rates to be varied by adjusting the pump duration (in seconds of operation) and pump activation. A setting of 0.4 sec x 4 operates the pump for 0.4 seconds every 4 axles.

Initially TOR applicators were spaced 2,700 feet apart and then later relocated 8,550 feet apart. These included spacing at 2,700 feet with application rates of 0.4 sec x 8 axles and 0.4 sec x 4 axles, and spacing of 8,550 feet with an application rate 0.4 sec x 8 axles. During each of these test configuration variations in lateral forces were monitored to determine effectiveness of the TOR system.

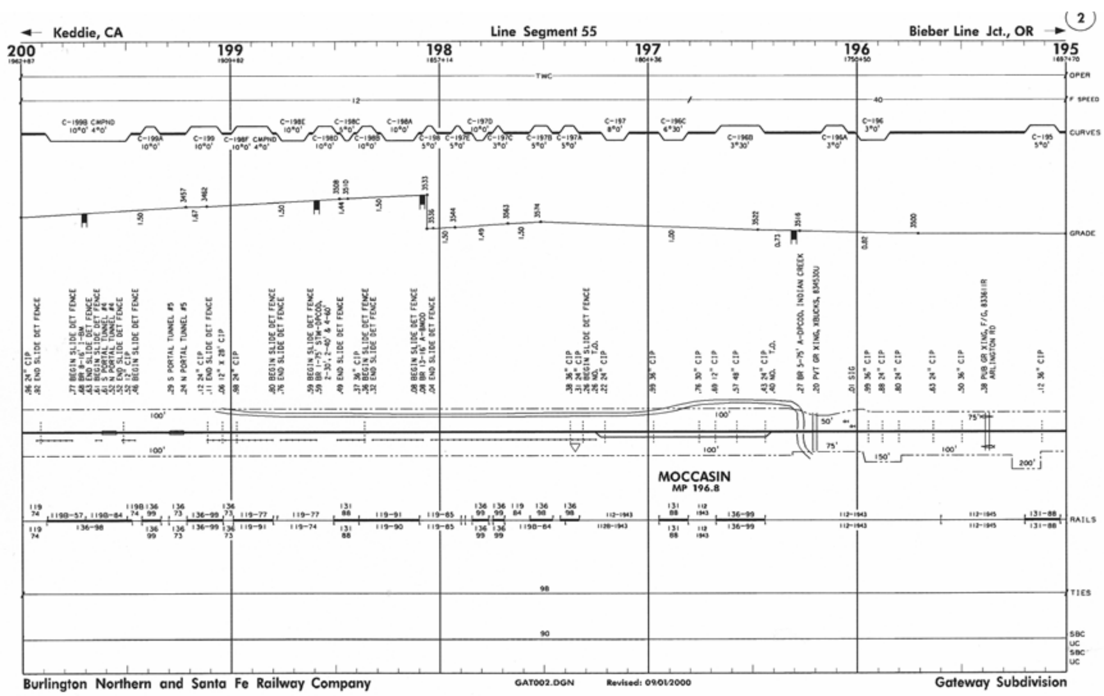

Figure 1. Track Chart of Test Area

Lateral Force Analysis

Lateral force data was provided by BNSF and forwarded to TTCI for evaluation. TTCI collected the data for analysis utilizing the following terms:

- Loaded cars with vertical load greater than 25 kips
- Lead Axles

These filtering methods focus on the most damaging forces for comparison between baseline and TOR treated rail.

Lateral Force Performance

A reduction in lateral curving forces was observed for virtually all configurations of TOR FM application rate and spacing. For purposes of evaluating application variations, comparisons utilize average curving forces generated during baseline (oo TOR – gage face lubrication only) and when the same gage face lubrication is amended with TOR FM using variations in applicator spacing and application rates.

Comparisons can also be made with Phase 1 demonstrations,[1] during which the reduction in lateral forces was consistent (within 10 percent) at applicator spacing of 1,900 feet, 2,700 feet, and 5,500 feet. Even at 5,500 feet spacing lateral force reductions ranged from 25 to 57 percent, depending on direction and location. Only minor changes in curving force performance were noted with changes in application rate during Phase 1.

Phase 2 results indicated a larger variation in percentage reductions from baseline related to changes in application rate and applicator spacing. During this second phase the highest reduction in lateral forces (range of 15 to 48 percent) occurred at the increased application of 0.4 sec x 4 (very high, non-typical) and 2,700 feet TOR applicator spacing.

Figures 2 and 3 illustrate the average curving forces at Crib 2 for east and westbound trains for various configurations evaluated during Phase 2. Tables 1 and 2 summarize lateral force reduction ranges for Cribs 1 and 2. It should be noted that the end of test return to baseline, titled “No TOR” did not reach the original baseline lateral force values. Heavy snowfall during the “No TOR” condition, which was at the end of this test, most likely lowered the lateral forces.

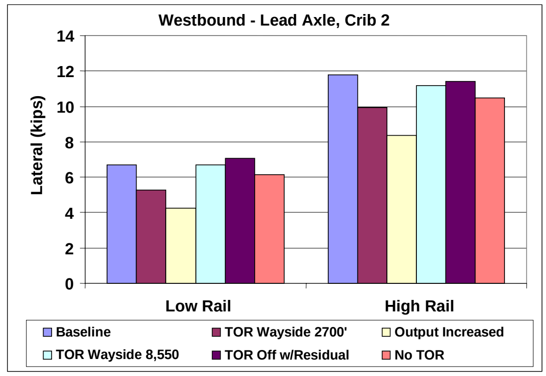

Figure 2. Crib 2 Westbound

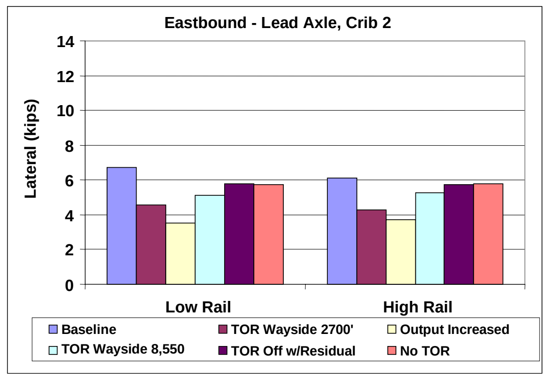

Figure 3. Crib 2 Eastbound

Table 1. Phase 2, Crib 2 Lateral Force Reduction during Different Application Rates

Spacing and Application Rates	Low Rail	High Rail
TOR 2,700 feet, 0.4 sec x 8 axles	-21 to -32 percent	-16 to -30 percent
TOR 2,700 feet, 0.4 sec x 4 axles	-36 to -48 percent	-29 to -49 percent
TOR 8,550 feet, 0.4 x 8 axles	0 to -24 percent	-5 to -14 percent

Table 2. Phase 2, Crib 1 Lateral Force Reduction during Different Application Rates

TOR Spacing and Application Rates	Low Rail	High Rail
TOR 2,700 feet, 0.4 sec x 8 axles	-28 to -29 percent	-3 to -29 percent
TOR 2,700 feet, 0.4 x 4 axles	-42 to -45 percent	-15 to -34 percent
TOR 8,550 feet, 0.4 x 8 axles	-3 percent to -15 percent	-15 to +7 percent

Influence of Rail Profile

Although the two phases had nearly identical conditions, a major change was made to the rail profile. This included installation of new rail (141AB) with a higher crown radius (8 inches), compared to a much flatter worn, conformal profile during the Phase 1 trials. Using WRTOL™ software developed by TTCI, typical freight wheel profiles were fitted on rail profiles collected from the test site during Phase 1 and Phase 2. This software predicts where the wheel/rail contact resides. As shown by Figure 4, conditions during Phase 1 produced a significantly wider contact area on worn rail. It has been suggested that the wider contact area during Phase 1 improved product pick-up at the applicators, resulting in increased carry down and subsequently greater lateral force reduction. In contrast, the new profile creates a smaller contact patch. This narrower contact patch also produces higher contact stresses. This likely resulted in greater dependence on TOR spacing and application rate, as the FM material had to function over a smaller contact patch area.

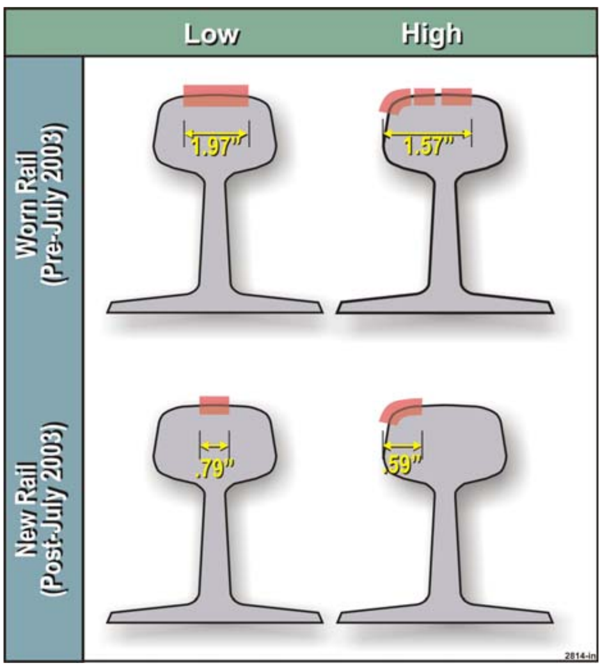

Figure 4. Phase 1 Rail Conditions

Future

Results from this demonstration suggest that while application of TOR materials can reduce curving forces, actual performance will depend on site conditions including applicator spacing, application rate, and rail profile. Other ongoing and planned programs sponsored by the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA) are evaluating these effects to improve implementation guidelines. The variably in results also suggest savings may be greater on older, worn/conformal rail than with new rail profiles.

Acknowledgements

A demonstration of this nature requires the participation and support of a number of groups. The local BNSF maintenance forces, along with Roadmaster Tom Smith, provided site support and assisted in access. Manal Bishr of the BNSF R&D Department collected and analyzed the field test results. Portec Rail Products assisted with applicator location and adjustment. Load station data was analyzed by Beatrice Rael of TTCI. Additional field support was provided by and Loerrella Maglalong of Kelsan Technologies.