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Effect of Top of Rail Friction Control on Rail Wear – Preliminary Findings

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Summary

An extension of the monitoring program for wayside-based top of rail (TOR) friction control, reported in TD-06-002,[1] was conducted under a cooperative program with the Association of American Railroads (AAR), CN, Kelsan Technologies Corporation, Portec Rail Products, and Transportation Technology Center, Inc. A major objective of this follow-up evaluation was to monitor rail wear rates over a wide range of curves. The test zones included a 10 mile controlled test zone with multiple wayside TOR applicators and nearby, but similar curves not protected by wayside TOR applicators.

Results suggest that the application of wayside-based TOR friction control statistically reduced rail wear rates of higher degree curves (greater than 5 degrees) by:

- Low Rail Vertical Wear: 20 to 39 percent
- High Rail Vertical Wear: 15 to 31 percent
- High Rail Gage Face Wear: 43 to 68 percent

Results were not as distinct for lower degree curves (≤5 degrees), where a mixture of reductions, increases, and no statistically significant changes were observed. As lower degree curves wear slower than high degree curves, they require more tonnage to produce a measurable amount of wear. Thus, small changes in wear rate add to inherent rail wear variability with the current data. Other demonstration locations have shown significant economic benefit of TOR,[2] thus the need to determine the effect of TOR friction control on rail wear rates.

The test site location on the Ashcroft Subdivision near Lytton, British Columbia, experiences approximately 98 percent uni-directional westbound traffic with a mixture of intermodal and loaded CN and Canadian Pacific Railway trains. Rail wear data was collected using optical rail profile runs.

During this phase of the trial, some spalling of the rail at or near a few TOR applicators was noted; however, these applicators were located directly adjacent to curve points and did not meet recommended TOR application placement guidelines. These locations were restricted due to adjacent curves and the general nature of the canyon alignment. There were no rail surface related issues noted at most TOR applicator locations.

This site incorporated a load measuring station to monitor the effectiveness of TOR application during the duration of the trail.

Results suggest rail wear savings of such a significant amount that additional rail wear monitoring is being conducted at other TOR demonstration sites to verify these values.

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Background

An extension of the monitoring program for wayside-based top of rail (TOR) friction control was conducted under a cooperative program with the Association of American Railroads (AAR), CN, Kelsan Technologies Corporation, Portec Rail Products, and Transportation Technology Center, Inc. (TTCI).

This follow up demonstration, after a preliminary single-unit trial, utilized multiple wayside-based applicators with a TOR friction modifier near Lytton, British Columbia. The primary goal of this program was to determine the impact of TOR friction modification on rail wear.

This trial follows the initial investigation that was reported in TD-06-002[1] that demonstrated basic placement guidelines for wayside-based TOR application systems.

Test Site Location and Details

The test site is located on the CN, Ashcroft subdivision, which experiences approximately 98 percent of traffic westbound loaded coal, grain, and sulfur trains as well as intermodal and mixed freight. During the test period, yearly traffic was 80 MGT, with up to 40 trains daily. A wide range of curvatures, many 8 degrees and higher, is encountered in this area.

Five TOR Portec Protector IV applicators were installed over a 10 mile zone and applied Kelsan KELTRACK® trackside TOR freight friction modifier.

Rail Data Collection

Bulk rail wear data, with a sample taken every 5 feet, was collected by CN's Optical Range Vision vehicle. Measurements were collected pre and post grinds to distinguish natural (train related) rail wear from metal removed by grinding. The measurement run and grinding dates are listed below:

- July 13, 2004
- August 16, 2004
- Grind: August 19, 2004
- August 25, 2004
- November 26, 2004
- Grind: December 3, 2004
- February 17, 2005 (erroneous data files)
- April 19, 2005

Data Analysis

Historical rail wear data (November 2002 to May 2003) was also available through CN's ARM databases, which employed a similar optical profile vehicle that collected same format data.

Raw, optical-based profile data is first checked for irregularities and then stored as the single point average rail profile for vertical and gauge face dimensions for each individual curve. The sampled points from Run 1 are subtracted from Run 2 to calculate the wear between the two runs. Each subsequent run is handled in the same fashion. The average wear for each curve is calculated and is normalized by tonnage.

Curve rail wear rate averages are then grouped according to:

- Similar degree of curvature Rail type
- Low Rail/High Rail

Rail wear periods are classified as:

- Natural wear: consistent operation and excludes grinding effects
- Macroscopic rail wear: contains several uncontrolled variables; includes grinding, changes in operation, that is, TOR product freezing, and different TOR applicator configurations

Table 1. Describes the Wear Periods Evaluated

Case	Designation	Dates	MGT	Contains Grinding	Other
1	Natural Wear	Jul 13 to Aug 16, 2004	7.74	No	
2	Natural Wear	Aug 25 to Nov 26, 2004	23.3	No	
3	Grinding Period	Aug 16 to Aug 25, 2004	2.12	Yes	
4	Macroscopic Run Subtracting grinding	Jul 13 to Nov 26 minus Aug 16 to Aug 25, 2004	31.1	No	
5	Macroscopic Run	Nov 26, 2004 to Apr 19, 2005	36.4	Yes	Including freezing, grinding, TOR unit configuration tests

Test Zones and Periods

A 5-mph increase in zone train speeds was implemented around July 2004, corresponding to the start of this program. This increase in train speed, as well as other factors such as changes in gage face lubrication, contributed to increased rail wear rates relative to historical rail wear in the baseline area. This invalidated direct comparison between historical rail wear rates and current TOR periods. Therefore, for this analysis the Ashcroft Subdivison was divided into three segments: Baseline, TOR, and Residual Zones.

The residual zone refers to those curves within 10 miles downstream of the TOR zone that may receive some residual effect due to carry down of the friction modifier. All curves outside the TOR and residual zones were considered untreated with TOR and became the baseline zone. Curves selected for comparison had the same traffic tonnage and the same measurement periods. The milepost range for each is tabulated:

- **Baseline Range:** Mile Post (MP) 76 to MP 86 and MP 106 to MP 125
- **TOR Range:** MP 86 to MP 98 (except for November 26 to April 19 wear period, MP 86 to MP 96 to remove effect of one unit's application to high rail only)
- **Residual Range:** MP 98 to 106

Rail Wear Results

Examples of all curve ranges measured during Cases 1 and 2 are shown in Figures 1, 2, and 3. Only the 136 RE type data is shown as this is the predominant rail in the area. Table 2 summarized these values for curves above and below 5 degrees. A "+%" indicates measured wear rates of curves in the TOR zone are greater than the non-TOR treated zone.

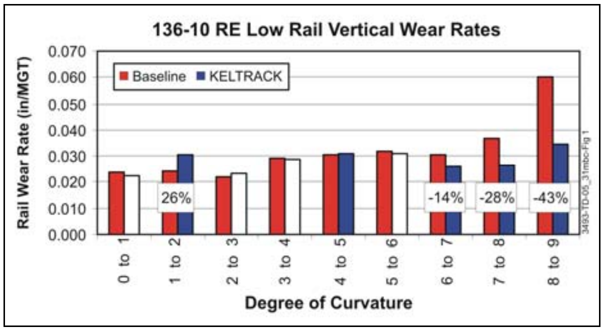

Figure 1. Case 1 and 2, 136 Low Rail Vertical Wear

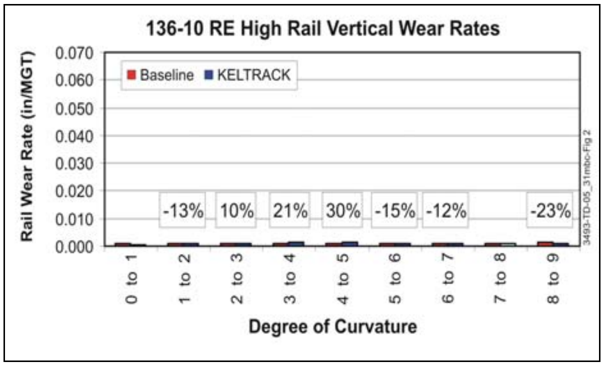

Figure 2. Case 1 and 2 High Rail Vertical Wear

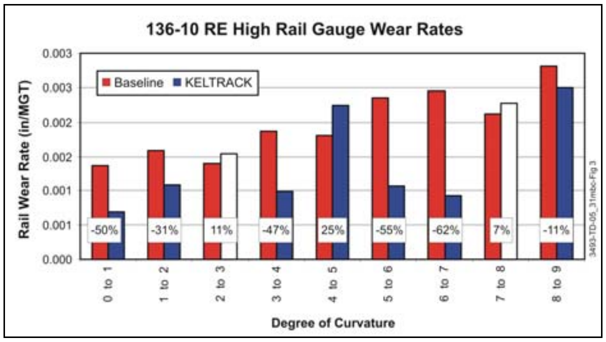

Figure 3. Case 1 and 2, High Rail Gage Face Wear

Table 2. Case 1 and 2, TOR Treated Rail Wear Rates Percent Difference from Baseline Rail Wear Rates

Degree of Curvature	Vertical Wear (percent)		Gage Face Wear (percent)
	Low Rail	High Rail	High Rail
> 5	-24%	-15%	-43%
=< 5	+26%	+11%	-8%

This same analysis methodology was applied to each case shown in Table 1. One variable observed from "pre and post" grinding measurements was that the amount of metal removed varied by location (range). Analysis combining 7.74 MGT and 23.3 MGT natural wear periods and the 2.21 MGT grinding period was utilized to create a 33.2 MGT (Case 1, 2, and 3) period.

The amount of metal removed during grinding was compared between the TOR and baseline zones. Results showed 20 percent less metal removed from the top of rail profile area in the TOR treated area and approximately 40 percent less metal removed in TOR treated gage face profile area. Because the amount of metal removed is not consistent between both test zones, each case/period must be evaluated separately to allow valid comparisons.

Results for Case 4 are summarized in Table 3; however, gage face data for this period appeared to have errors that could not be corrected.

Table 3. Case 4 TOR Treated Rail Wear Rates, Percent Difference from Baseline Rail Wear Rates

Degree of Curvature	Vertical Wear (percent)	
	Low Rail	High Rail
> 5	-39%	-31%
=< 5	-51%	+32%

Results for the final period (Case 5 – variable operating conditions) are summarized in Table 4.

Table 4. Case 5 TOR Treated Rail Wear Rates Percent Difference from Baseline Rail Wear Rates

Degree of Curvature	Vertical Wear (percent)		Gage Face Wear (percent)
	Low Rail	High Rail	High Rail
> 5	-39%	-15%	-68%
=< 5	-16%	+0.88%	-54%

Results summarized in Tables 2, 3, and 4 suggest TOR application reduced rail wear rates of sharper curves (> 5 degrees) by:

- Low Rail Vertical Wear: 20 to 39 percent
- High Rail Vertical Wear: 15 to 31 percent
- High Rail Gage Face Wear: 43 to 68 percent

Results were not as distinct for lower degree curves ($\leq$5 degrees), where a mixture of wear rate reductions or increases were statistically insignificant. As lower degree curves wear more slowly than higher degree curves, they require more tonnage to produce a measurable amount of wear. Thus, small changes in wear rate add to inherent rail wear variability with the current data.

Future Work

The effect of TOR friction control on rail wear rates appears to be significant, with data from this CN site suggesting wear rate reductions of greater than 20 percent during most periods. This can have significant advantages to the cost/benefit analysis and justification for implementing TOR friction control. As these numbers are important to the industry in determining investment options, additional rail wear monitoring on a similar deployment configuration is being conducted. Rail wear measurements were implemented January 2006 at the Union Pacific Railroad site, near Walong, California.

Future investigations at the CN, Lytton site will evaluate alternative applicator spacing and applicator output rates. Because these variations will make monitoring rail wear under constant TOR conditions difficult, other sites have been selected for such evaluations.

Results from these and other monitoring efforts will be used to update best practices implementation guidelines to ensure TOR friction control systems are deployed in the most cost effective manner to achieve needed reductions in curving forces and obtain adequate control of rail wear rates. To allow performance to be monitored during this next investigation a load measuring station will be utilized.

Continued evaluation and assessment of results will be utilized in development of implementation and deployment guidelines for wayside-based TOR. These guidelines will be incorporated into Chapter 4 (Rail) of the AREMA Manual of Recommended Practices.

Acknowledgements

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References

1. R. Reiff and D. Lilley, “Preliminary Placement Guidelines TOR Friction Control Application Systems, TTCI Technology Digest TD-06-002, February 2006.
2. T. Guins, “Economic Analysis of Top Of Rail Friction Control – Walong, CA,” TTCI Technology Digest TD-05-019, August 2005.