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Implementing Top of Rail Friction Control on Norfolk Southern Preliminary Results of Rail Wear Rates

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Summary
Results of a preliminary demonstration of top-of-rail (TOR) friction control were sufficiently encouraging;[1] and therefore, a more rigorous monitoring program has been implemented on a larger scale. In 2009, a new demonstration site on the Bluefield-Williamson subdivision of the Norfolk Southern (NS) Railway was initiated by NS and Transportation Technology Center, Inc. (TTCI) under funding provided by the Association of American Railroads (AAR) Strategic Research Initiatives Program. NS and TTCI engineering staff teamed to monitor rail performance on a segment between Old Joe to White where TOR friction control and optimized gage-face (GF) lubrication was introduced. Data collected over 18 months suggests that curves where TOR has been implemented exhibited reduced rail wear, improved rail surface conditions, and reduced required metal removal when grinding. Reliability of application equipment and susceptibility to vandalism is still being evaluated and will be summarized in a final report.

The 20-mile Old Joe to White test area is located east of Williamson, West Virginia, on a double track section of NS with approximately 60 million gross tons (MGT) of annual traffic. Predominant MGT consists of loaded and empty coal trains, but is mixed with an increasing number of intermodal and double stack trains. Two test zones were used: (1) A 10-mile control zone on main track one of double track that was equipped with GF lubrication and (2) an adjacent 10-mile test zone on main track one that was equipped with the same GF lubrication plus the addition of TOR friction control. All rail in the two zones was 136 RE head hardened rail from two suppliers and was installed in July 2009. Curves of 3 to 12 degrees were monitored for rail wear in both zones. Rail vertical wear rate changes due to TOR vary from having no effect to 49 percent decrease, depending on curvature and location (high or low rail). A similar range of benefits was noted in head area wear.

The effect of wayside TOR friction control on rail wear was determined by comparing curves of similar curvature in the control zone (GF only) to the test zone (GF+TOR). Because this is a double track area and trains cross over from one track to the other within zones, the tracking of trains by track within the test areas was required. This was to ensure that all rail wear measurements were normalized by tonnage and could be compared on an equal basis (i.e., rail wear rate).

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INTRODUCTION

Improved rail life and rail surface performance has been documented at monitoring locations where TOR friction control has been implemented.[1,2] However, some of these tests either had a limited range of curvatures or a variety of rail conditions, making system wide benefits difficult to determine. In addition, earlier evaluations utilized prototype TOR application systems; thus, reliability and maintenance demands of current, state-of-the-art equipment could not be determined.

OBJECTIVE

The objective of this project is to determine the effect of combined GF lubrication and TOR friction control on a range of curvatures by monitoring rail wear rates and the formation of rolling contact fatigue (RCF). Also, the ability of local crews to maintain TOR applicators were monitored, which will be documented in a final report.

METHODOLOGY

A 20-mile section of double track was selected with the monitoring of rail performance on main track one. Both test zones had improved GF lubrication, with approximately half of the 20 miles receiving TOR friction control. For 18 months, the site was monitored for rail performance, including grinding and maintenance and reliability of application systems.

The effect of TOR friction control on rail wear rate was assessed by comparing nine curves in the GF+TOR zone to nine curves in a nearby GF only zone. Similar 3- to 12-degree curves were selected in each zone for back-to-back comparisons. Wheel loads and train operations were monitored in both zones so that rail wear could be normalized by tonnage to determine rail wear rate.

In each of the 18 rail wear curves, six measurement sites were established in the full body of the curve. MiniProf™ rail profile measurements were taken approximately every four months, which were coordinated just prior to and after rail grinding. During these measurements, the formation of RCF was monitored by performing a dye penetrant test on the railhead and photographing the result.

The double-tracked Old Joe to White test area is subjected to branch line traffic from a number of coal mines and multiple crossovers As a result, tonnage at some curves is different than others. To compensate for the variation in tonnage, NS installed vertical load rail force monitoring stations at key crossover and branch line points to determine the day-to-day traffic density.

TEST SITE LAYOUT

Figure 1 shows curve locations, identified by letters, where rail performance was monitored. Curves A-J (green band) received GF lubrication only, while curves M-V (yellow band) received GF lubrication and TOR friction control. Codes I and Q were not used. During the test, the rail in curve D was replaced due to a tunnel tie project and curve K was added for monitoring purposes (but not included in this analysis because the wear data obtained was not for the full period of testing).

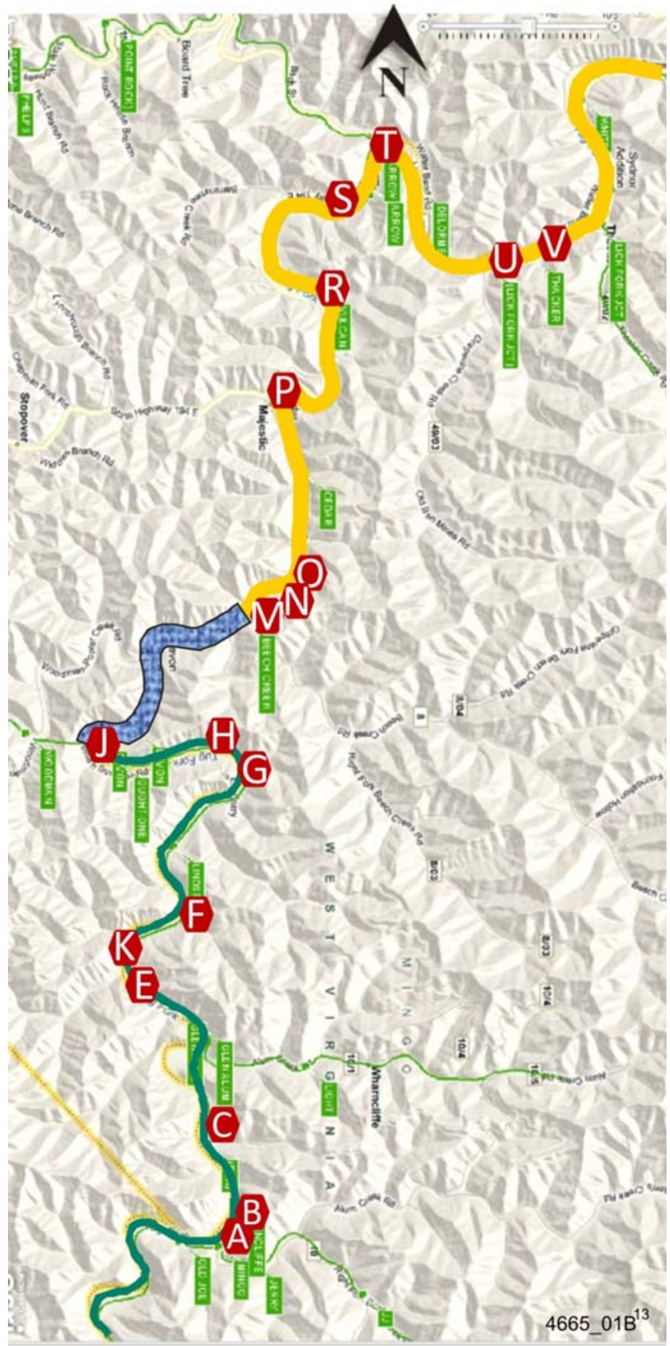

Figure 1: Site Map showing Test Curve Locations. The Yellow Band designates Curves with both TOR Friction Control and GF Lubrication. The Blue Band designates a Transition Zone, and the Green Band is the Control GF Only Zone

Table 1 shows the breakdown of curvatures and comparisons for the preliminary evaluation.

Table 1: Figure 1 Curvatures and Location ID Codes

Curvature Range	TOR + GF	GF Only
3-degree	R, T	A, E
5- to 6-degree	M, N, O, S, U, V	B,C,F, G, H
12-degree	P	J

RESULTS

MiniProf rail profiles were overlaid using the first measurement as the baseline and comparing subsequent measurements. From this analysis, vertical head wear and total area loss were determined for each measurement location in each curve. These measurements were then used to determine an average wear value for the high and low rails of each curve. At this early stage in rail life, some curves are exhibiting metal flow from the top to the side (gage). Vertical wear is exceeding lateral wear, which results in the Miniprof measurements showing the rail is getting wider. Thus, GF wear is not included in the current analysis.

Figure 2 shows tonnage (MGT) versus vertical head wear history of Curve V, and Figure 3 shows the head area loss for the same curve. The longer periods of tonnage between measurements indicate steady state wear, and the shorter periods represent the wear between pre- and post-grind measurements.

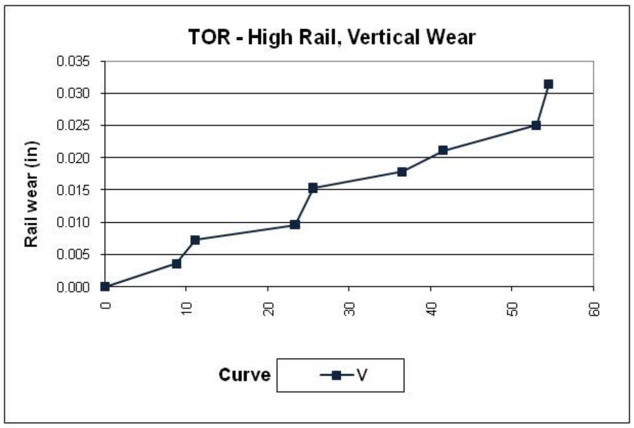

Figure 2. Typical Vertical Wear by Tonnage (MGT), Curve V

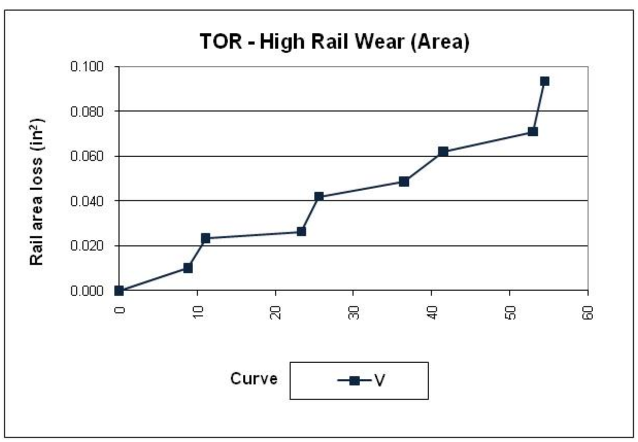

Figure 3. Typical Head Area Loss by Tonnage (MGT), Curve V

The slope of each "longer" period represents the average wear rate during steady state conditions, and the amount of metal removed during each grinding period can be determined by subtracting post- and pre-grind values.

Figures 4–5 summarize average wear rates for the groups of curves in Table 1 for all four steady state periods. This covers approximately 60 MGT of traffic over 18 months.

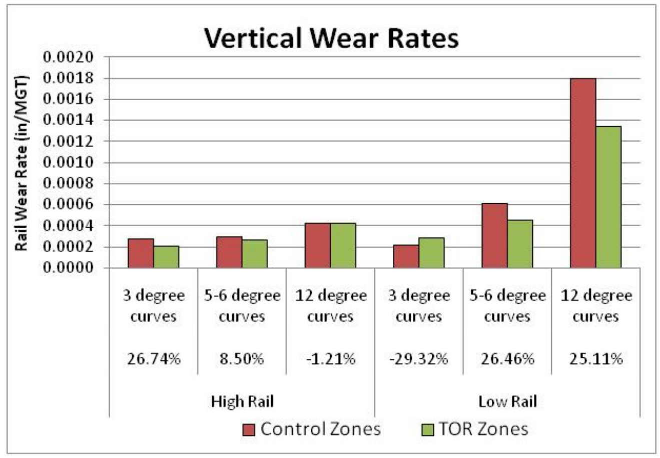

Figure 4. Wear Vertical Head Wear Rate for all Curves. Percent Difference between Control (GF only) and TOR (GF+TOR)

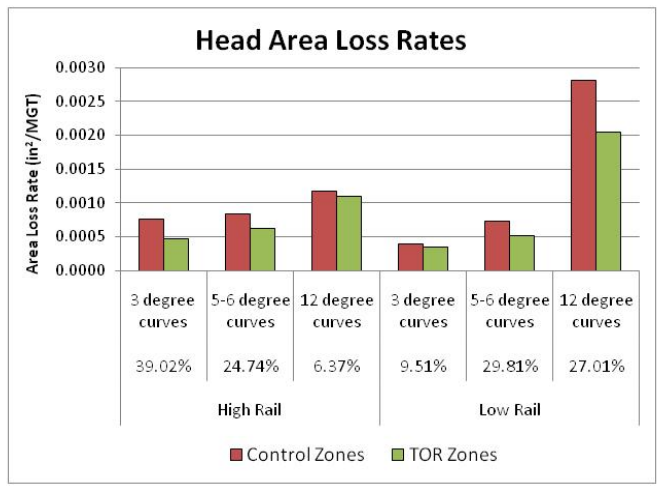

Figure 5. Head Area Loss Rate for all Curves. Percent Difference between Control (GF only) and TOR (GF+TOR)

Wear rate results suggest that in most locations, TOR friction control improved rail wear life except for the low rail of 3-degree curves. This may be due to the small amount of wear occurring in these 3-degree curves, which is near the measuring tolerance of the MiniProf instrumentation. To determine if these rates are statistically different, additional tonnage and wear will be required

During the monitoring period, the rail in the test area was ground four times, which is shown by increases in wear in Figures 2 and 3. A pre-grind inspection of the rail profile and surface was made by NS to determine the number of passes and amount of metal required to be removed. This inspection was conducted without influence or knowledge of where TOR friction control was being used. Figures 6 and 7 show the amount of metal removed for the 1st and 4th grinding periods, which represents what was elected to be removed in order to restore the rail to its proper condition. The 2nd grinding period is not shown because some curves were skipped due to traffic problems, and the 3rd grinding period had corrupted data, which prevented accurate grinding data to be determined. As a result, average grinding was computed using only the first and fourth grinding periods.

Rail surface condition is a significant factor in determining how much metal to remove when grinding. Visual and dye penetrant inspection of the rails suggested that surface cracks and overall appearance in the TOR (GF+TOR) zone was improved over that in the GF only zone. Although comparisons based on visual indications are somewhat subjective, the amount of grinding is a measurable parameter. Figures 6 and 7 show that for all ranges of curvatures, more metal was removed from curves in the GF only zone when compared to the TOR+GF zone. Other tests evaluating TOR friction control indicate the same trend.[3]

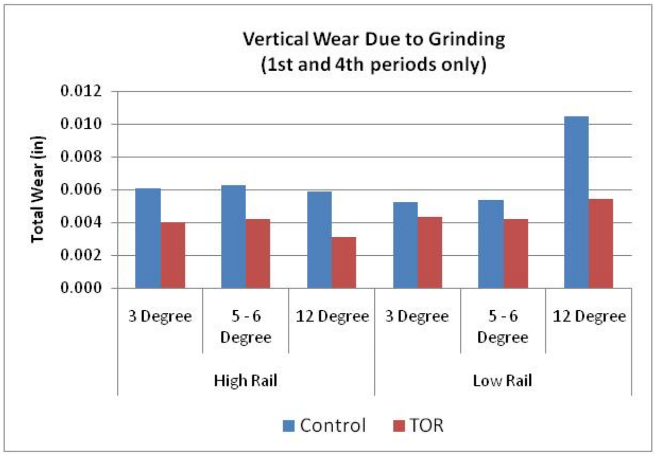

Figure 6. Average Vertical Grinding for Groups of Curvatures

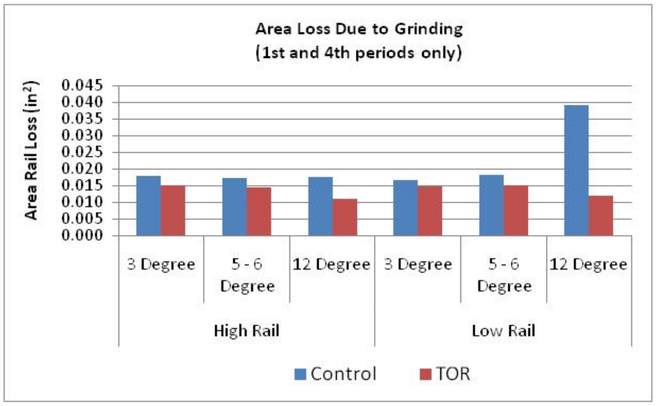

Figure 7. Average Head Area Loss due to Grinding for Groups of Curvatures

It should be noted that one set of curves (S and T) in the TOR zone performed worse than all the others. Evaluation of operations in these areas indicated that numerous trains are routed to and from a branch line that does not receive TOR. Thus, wheels that are not conditioned with TOR material frequently travel over these two curves. Plans are to install a TOR system in this area to determine if this is the case or not.

SUMMARY AND CONCLUSIONS

On average after ~60 MGT of traffic, GF+TOR treated curves exhibited less wear and required less grinding than identical GF only treated curves. TTCI and NS will continue to monitor this area and issue a final report, including an assessment of applicator maintenance and reliability issues.

Acknowledgments

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