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# Demonstration: Implementing Top of Rail Friction Control on Norfolk Southern

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## Summary

Under funding provided by the Association of American Railroads (AAR) Strategic Research Program, Transportation Technology Center, Inc. (TTCI) and Norfolk Southern (NS) teamed to monitor rail performance at an NS revenue service location where top of rail (TOR) friction control is being introduced. Data collected over two years suggests reductions in curving forces and train energy were obtained in an area where TOR friction control has been implemented.

This test location is located near a long-term heavy axle load revenue service test being conducted on NS between Bluefield, West Virginia, and Narrows, Virginia. The test location includes a 15-mile section of double track that uses gage face lubrication and TOR friction control and a similar section of track about 20 miles away that is not using TOR friction control.

The effect of wayside TOR friction control on rail wear was monitored by comparing six curves in the TOR treated area to six curves in the non-TOR treated area. Wheel loads and train operations are similar between the two areas. On average, rails with TOR treatment exhibited less wear and less rail surface degradation than those without TOR treatment after three years and 180 million gross tons of revenue service. Direct comparisons of the test results were difficult, because of differences in rail type, age, and wear at the beginning of the test.

In addition, the top running surface condition of rails in the TOR treated zone exhibited less degradation than the adjacent, non-TOR treated zone. Again, as with comparisons of rail wear, initial rail conditions and age differences between the two zones made direct comparisons difficult.

The results of this preliminary demonstration were sufficiently encouraging, suggesting a more rigorous monitoring program that has been subsequently implemented. The new demonstration site is at the “Old Joe” subdivision, which is located approximately 100 miles west of Bluefield, West Virginia. Monitoring of rail performance at the Old Joe site was initiated late 2009, and results will be reported in a future *Technology Digest*.

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## INTRODUCTION

Reductions in curving forces and train energy have been documented at monitoring locations where TOR friction control has been implemented. Because many of these locations have not been operational for long periods of time, the effect of TOR friction control on rail wear has not yet been determined.[1] Other studies have shown that rail wear and rolling contact fatigue (RCF) are a function of both gage face lubrication and TOR friction control conditions.[2]

## OBJECTIVE

The objective of this project was to determine the effect of gage face lubrication and TOR friction control on rail wear and the formation of RCF.

## METHODOLOGY

A long-term heavy axle load (HAL) revenue service test to investigate the effect of gage face lubrication and TOR friction control on track component performance was conducted on the NS between Bluefield, West Virginia, and Narrows, Virginia. A 15-mile section of double track, implemented with gage face lubrication and TOR friction control, was monitored for track component performance, including rail, ties, and track degradation.

The effect of TOR friction control on rail wear was assessed by comparing six curves in the TOR treated area to six curves in the non-TOR treated area. Wheel loads and train operations are similar between these two areas.

For each test curve, six measurement sites were established at even intervals along the curve. MiniProf™ rail profile measurements were made approximately every six months, and when possible 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.

Because rail wear is a long-term event, rail force monitoring stations were also utilized to determine the day-to-day effectiveness of the TOR systems. When the TOR systems were operational, curving forces showed 20 to 30 percent reductions, and this value was used to determine whether or not the TOR systems were functioning properly.

## TEST SITE LAYOUT

Six curves were selected in each zone for monitoring rail wear and the formation of RCF (Table 1). Because the non-TOR treated zone was at a single track location and the TOR treated zone was at a double-track location, the accumulated tonnage, i.e., million gross tons (MGT), for the zones was different. In addition, tonnage determination for the double-tracked TOR zone was complicated by several track crossovers, allowing trains to change from one track to the other.

**Table 1. Rail Wear Monitoring Zones**

| Non-TOR Zone | | | TOR Zone | | |
|---|---|---|---|---|---|
| ID | MP | Curvature | ID | MP | Curvature |
| A | V293.2 | 6.0R[1] | M | N342.5 | 5.8,6.0R[1] |
| B | V296.3 | 5.0,4.8L[1] | N | N348.1 | 5.3L |
| C | V297.5 | 6.8,5.6R[1] | P | N353.2 | 6.2R[1] |
| D | V297.9 | 5.8,6.3R[1] | R | N353.6 | 6.8L[2] |
| E | V303.3 | 5.9L[1] | S | N353.7 | 6.2R[3] |
| F | V303.6 | 5.9L[1] | | | |

[1] Compound curve
[2] TTCI force monitoring site
[3] NS force monitoring site

## RESULTS

MiniProf rail profiles were overlaid, using the first measurement as the baseline and comparing subsequent measurements to it. From this analysis, gage face wear, vertical head wear, and total area loss were determined for each measurement location in each curve. Then, these measurements were used to determine an average wear value for the high rail and low rail of each curve. Figure 1 compares the average low rail vertical wear for all curves for all measurement cycles in the TOR and non-TOR treated zones.

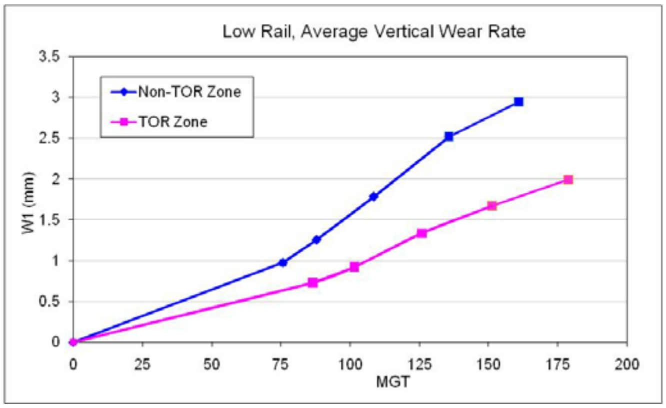

**Figure 1. Average Vertical Wear, All Curves, TOR and non-TOR Treated Zones**

Figure 1 shows differences in tonnage between the two sites and variations in wear during the monitoring period. Figures 2 and 3 show the average vertical wear rates for the low and high rail respectively for the non-TOR and TOR treated zones. Data was further broken down to show the wear rate due to traffic (wear only) and the wear rate due to rail grinding (grind) when pre- and post-grind measurements were made.

As Figures 2 and 3 show, high and low rail vertical wear rates showed similar trends. High rails in the TOR treated zone exhibited 18 percent less wear and the low rails exhibited 35 percent less wear than the non-TOR treated zone. Metal removed from grinding was also significantly less in the TOR treated zone than in the non-TOR treated zone.

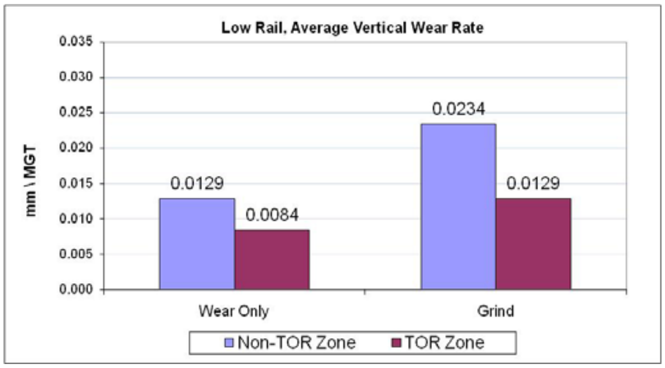

**Figure 2. Low Rail Vertical Wear Rates, TOR and non-TOR Treated Zones**

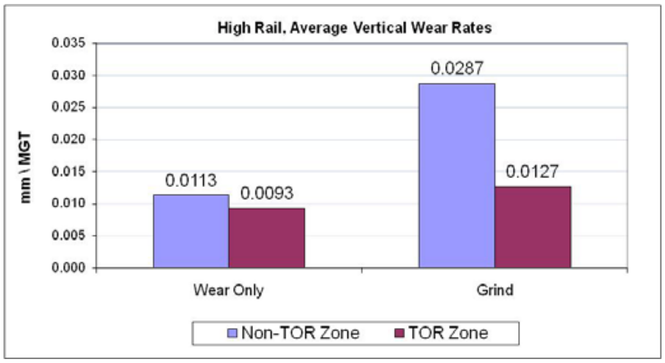

**Figure 3. High Rail Vertical Wear Rates, TOR and non-TOR Treated Zones**

Figures 4 and 5 show the same wear rate data for the high rail gage face and high rail total area loss respectively.

The gage face wear rate was higher in the TOR treated zone than in the non-TOR treated zone. This may be due to the fact that some rails were more worn than others when the test began and had an established gage face angle. As information, the MiniProf uses the top running surface of the rail to determine the 5/8-inch down point for gage face wear measurement location. As the rail wears vertically, this point is lowered to a different and wider location of the gage face angle. While complicated data analysis is required to correct for the change in location, by examining the total head area loss, which takes into consideration both vertical and gage face metal loss, the TOR treated zone still shows about 7 percent less wear, as Figure 5 shows.

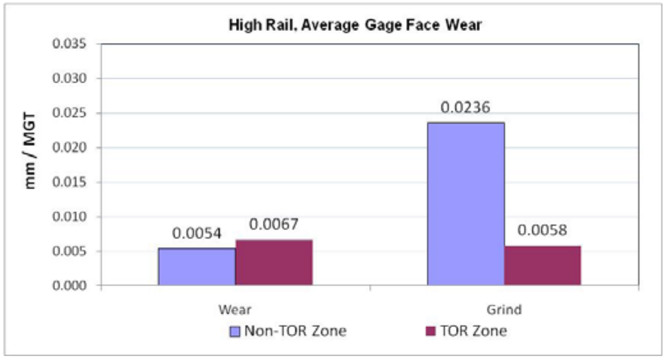

**Figure 4. High Rail Gage Face Wear Rates, TOR and non-TOR Zones**

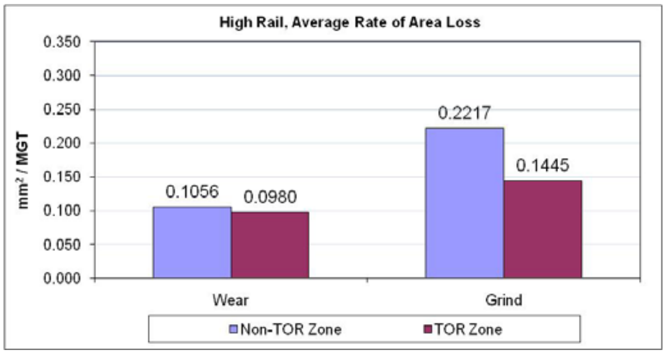

**Figure 5. Total Area Loss, High Rail, TOR and non-TOR Treated Zones**

Figure 6 shows an example of multiple rail profiles overlaid during 180 MGT periods showing head area loss and the gage face angle. Note the initial profile at the start of monitoring was of existing, worn rail.

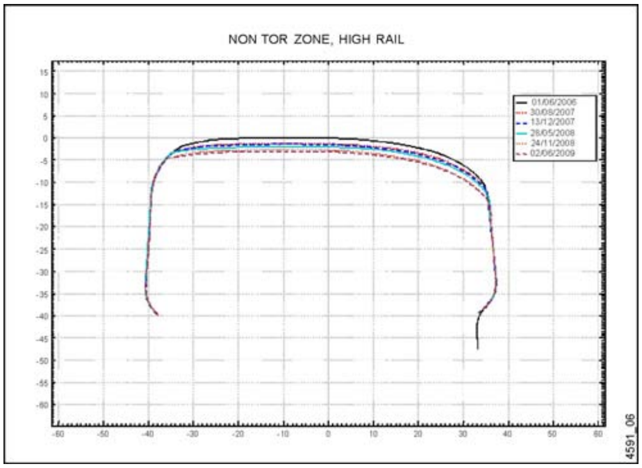

**Figure 6. Multiple Rail Profiles Overlaid during 180 MGT**

## RAIL SURFACE PERFORMANCE

In addition to measuring rail profiles, the surface of the rails was examined for surface cracks and overall appearance. For this test area, existing rails from a wide range of suppliers and ages were utilized; thus, the starting conditions were not the same for each site.

Other tests evaluating TOR friction control used new head-hardened rails installed in 2009, which indicated little or no RCF cracking in over 200 MGT and no interim grinding.[3] However, the existing rails already exhibited signs of RCF at the start of monitoring in the TOR and non-TOR treated zones. As a result, comparisons are limited to showing changes in RCF during the 180 MGT period, as opposed to assessing if RCF was formed or not.

Although these comparisons are subjective, Figures 7 to 10 show similar examples of the surface condition of most rails from each zone. Rails in the TOR treated zone showed the same or less RCF after three years, as compared to rails in the non-TOR treated zone, which exhibited increased amounts of RCF.

Figure 7. Low Rail of Curve S in the TOR-treated Zone at Site 3 Start of Test April 2006

Figure 8. Low Rail of Curve S in the TOR-treated Zone at Site 3 End of Test June 2009

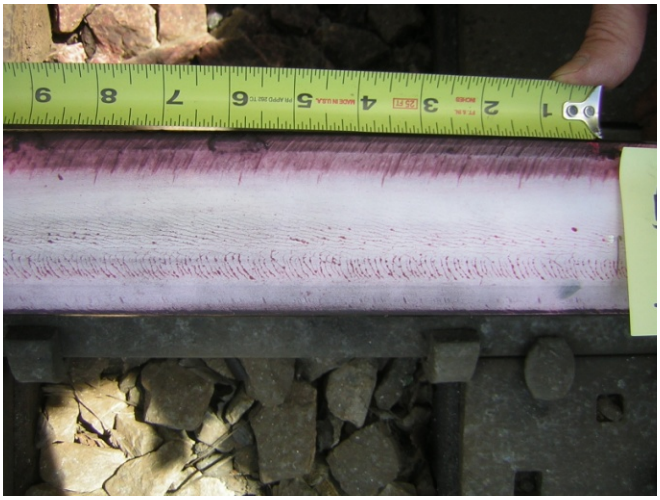

Figure 9. Low Rail of Curve D in the non-TOR Treated Zone at Site 5. Start of Test April 2006

Figure 10. Low Rail of Curve D in the non-TOR Treated Zone at Site 5. End of Test June 2009

## SUMMARY AND CONCLUSIONS

On average, the TOR treated rails exhibited less wear and less rail surface degradation than the non-TOR treated rails after three years/180 MGT of service. Differences in rail type, age, and wear condition at the beginning of the test made direct comparisons difficult.

## FUTURE WORK

To address the issues associated with differing rail metallurgy, rail age, and tonnage determination, TTCI and NS have initiated a similar rail wear monitoring program between Iaeger, West Virginia, and Williamson, West Virginia. Monitoring is currently underway to assess wear rates in curves for non-TOR and TOR treated rails.

## Acknowledgments

During the test period, support from the following personnel at NS was essential in ensuring proper applicator operation, inspection and reporting: Rob Holloway, Dwayne Gibson, Mack Carbaugh, and Kenny Smith.

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