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RESEARCH RESULTS

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# CONTROL OF ROLLING CONTACT FATIGUE ON PREMIUM RAILS IN REVENUE SERVICE

## SUMMARY

Effective rail maintenance strategies are essential for controlling rolling contact fatigue (RCF) and reducing wear of rails under heavy axle load (HAL) operations. In an effort to optimize rail maintenance strategies in revenue service, Transportation Technology Center, Inc. (TTCI) has been investigating top-of-rail (TOR) friction control and preventative grinding practices for control of RCF.

Rail performance testing has been conducted in revenue service since the fall of 2005 at the eastern and western mega sites near Bluefield, WV, and Ogallala, NE, respectively. Initially established to supplement rail performance testing conducted at the Facility for Accelerated Service Testing (FAST) in Pueblo, CO, the scope of testing in revenue service has since been expanded to include evaluation of rail maintenance strategies. This includes evaluation of the long-term effects of gage-face (GF) lubrication, TOR friction control, and corrective or preventative grinding practices. Test results are providing valuable feedback regarding the effect of such strategies on the service life expectancy of rail in HAL revenue service.

Thus far, the results obtained from testing at the mega sites have been very promising with regard to lower rates of railhead wear, prevention of RCF, and absence of internal defects. At the western mega site, for example, a statistically significant reduction was observed in the rate of wear for both high and low rails in 2-degree curves following the implementation of TOR friction control, and only intermittent RCF growth was detected after approximately 1,000 MGT (see Figure 1).

TTCI conducts this research under the HAL revenue service program cosponsored by the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA).

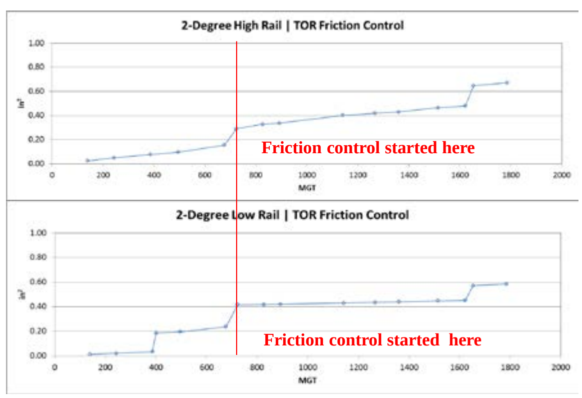


Figure 1. Average rail wear results from traffic and grinding at the western mega site

## BACKGROUND

In 2005, TTCI, with the cooperation of the host railroads, Union Pacific and Norfolk Southern, established premium rail performance test locations at both the western and eastern mega sites to supplement rail performance testing at FAST. In 2008, the scope of testing at the western mega site was expanded to include evaluation of rail maintenance strategies to control wear rates and RCF growth. The eastern mega site has used GF lubrication and TOR friction control at all test curves since the initiation of testing in 2005.

The western mega site, located on Union Pacific's South Morrill Subdivision, has three test curves containing seven premium rail grades from six manufacturers and sees 200–250 MGT of traffic annually. The curves are comprised of two 2-degree curves and one 1-degree curve, both employing 141 RE rail on standard concrete ties with elastic fasteners.

The eastern mega site, located on Norfolk Southern's Virginia Division, has four test curves containing eight premium rail grades from four manufacturers and sees an estimated 55 MGT of traffic annually. The curves are comprised of two 6.8-degree curves and two 10-degree curves made up of 141 RE rail on timber ties with a cut-spike fastening system.

## OBJECTIVES

The primary objective of this test is to evaluate the performance of premium rail in the HAL revenue service environment. A secondary objective, established later for the western mega site only, is to evaluate the long-term effects of different rail maintenance strategies on premium rail in the HAL revenue service environment.

## METHODS

TTCI has conducted inspections and measurements of the rail at both the western and eastern mega sites on a semiannual basis since 2005. Inspections were completed using visual and dye penetrant nondestructive examination. Railhead cross-sectional profiles and running surface hardness measurements were gathered regularly.

## RESULTS

### Western Mega Site

At present, the premium rails installed in the test curves at the western mega site have accumulated more than 1,800 MGT of traffic and have maintained excellent wear performance throughout the course of the experiment.

For all three test curves, no rail maintenance strategies, except for the application of lubrication to the GF, were implemented during the early stage of the experiment. For the 2-degree curves, RCF started to appear on the low rails at approximately 300–350 MGT. As a result, two corrective grindings were implemented before 700 MGT to remove the RCF. After 700 MGT, TOR friction control was implemented for one of the 2-degree test curves, while the other began receiving scheduled preventative grinding every 70 MGT, per the recommendations from earlier modeling results.

As a result of TOR friction control, a corrective grind was not required until 1,650 MGT of traffic to remove RCF, which took much longer to recur (i.e., 950 MGT).

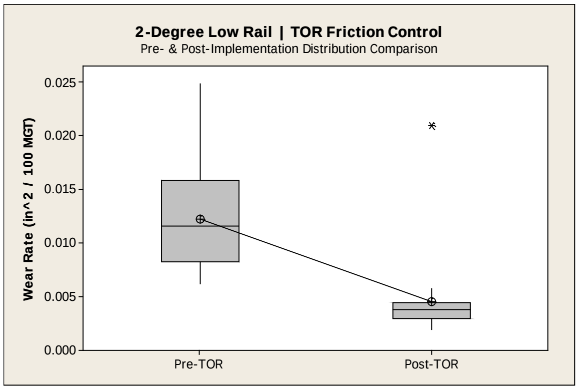


**Figure 2. Rates of wear across all rail grades at the western mega site**

Figure 2 shows the distributions of the rates of wear for all test rails before and after the implementation of TOR friction control for the 2-degree curve. Statistical testing was conducted to compare the rate of wear before and after implementation of TOR friction control within the 2-degree test curve. Results have shown that there was a reduction in the rate of wear following the implementation of TOR friction control for both the high and low rail.

Since the implementation of rail maintenance strategies at 700 MGT, the median railhead area loss for the 2-degree curve using TOR friction control is measured at 7.1 and 3 percent for the high and low rails, respectively. By contrast, the median railhead area loss for the 2-degree curve implementing preventative grinding is approximately 11.6 and 7.9 percent for the high and low rails, respectively. Although preventative grinding is effective in controlling the spread of RCF, it can lead to more railhead area loss.

Preventative grinding, generally consisting of a single pass, saves on railhead area loss, especially when compared with corrective grinding actions, which typically require multiple passes.

The 1-degree test curve did not incorporate any of the rail maintenance strategies seen at the 2-degree test curves. Though no internal fatigue defects have been identified, severe sporadic surface defects consistent with spalling developed at multiple locations on the high rail, which led to the eventual removal of the test rail at 1,782 MGT.

## Eastern Mega Site

With approximately 415 MGT accumulated to date, the premium test rails at the eastern mega site continue to show excellent wear performance and resistance to internal fatigue.

The surface condition of the rails within the test curves was excellent until approximately 250 MGT when the low rails within the two 10-degree test curves began to show signs of RCF. An additional 100 MGT was accumulated before the 6.8-degree test curves began to show similar signs of RCF growth on the low rail. A corrective grind to address RCF was performed at 275 MGT and 365 MGT for the 10- and 6.8-degree test curves, respectively.

For the 10.5-degree test curve under normal traffic, the median area railhead loss per 100 MGT is 0.09 $in^2$ and 0.11 $in^2$ for the high and low rails, respectively. The 6.8-degree test curves, on the other hand, typically wear at a median rate of approximately 0.04 $in^2$ per 100 MGT for both rails.

At approximately 300 MGT, the low rail within the two 10-degree test curves began to show field-side plastic flow. At 415 MGT, the plastic flow formed a distinct 0.2-inch lip on the field side of the railhead at multiple locations throughout the curve.

## CONCLUSIONS

Long-term testing efforts at both the western and eastern mega sites have shown that lower rates of railhead wear, prevention of RCF, and absence of internal defects are among the benefits associated with the implementation of rail maintenance strategies under HAL. Results suggest that TOR friction control and preventative grinding were quite effective in addressing the development and growth of RCF. By utilizing TOR friction control and preventative grinding, it is expected that the service life of rail under HAL conditions will increase.

## FUTURE ACTION

TTCI and host railroads are in the process of installing additional test curves at both mega sites with the goal of evaluating a hybrid maintenance strategy combining the benefits of TOR friction control and some preventative grinding on an optimized schedule. Also, another test curve will be established to evaluate the long-term effects of similar rail maintenance strategies on intermediate strength rail in high-degree curvatures.

## ACKNOWLEDGEMENTS

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## KEYWORDS

Rail life extension, premium rail, revenue service