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Update on Cold Weather Evaluation of Premium Rail Performance

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Key Findings:

- Three rail types are showing statistically less wear than others at 219 MGT of accumulated tonnage.
- Early RCF issues appear to have been addressed with grinding and lubrication adjustments.
- Only one premature rail failure, a flash butt weld, has been documented in the test curve. No service failures of the rail have occurred to date.
- Several flash butt welds have begun to batter and will be removed from track if the host railroad deems necessary.

Under the Association of American Railroads (AAR) Strategic Research Initiatives Program, [Transportation Technology Center, Inc. \(TTCI\)](#) has been evaluating the performance of premium rail steels under cold weather climate conditions since 2014 at a northern mega site near Winnipeg, Canada. Data collected through approximately 219 MGT of accumulated tonnage has begun to show some separation in the wear characteristics of the different vendor rails, with three rail types showing statistically less wear than the others.

In December 2014, a test to evaluate rail steels formulated for superior cold weather performance was initiated on the Redditt Subdivision of Canadian National Railway (CN) in western Ontario. Test rails were obtained from five vendors and were installed along with one control rail type provided by CN. The rails were installed in a nominal 5-degree, 1,000-foot curve at milepost 111 on both the high and low rails. The test location accumulates approximately 55 MGT per year. Traffic consists of mixed freight and intermodal with loaded traffic biased in the eastbound direction. The maximum speed through the curve is 35 mph, with 30 mph being balance speed.

This *Technology Digest* presents an overview of the test location and layout, as well as comparisons of wear measurements for six rail types and one control rail type on the high and low rail of the 5-degree, 1,000-foot curve. Comparisons include total area loss, rolling contact fatigue (RCF) classification, and Brinell hardness (BHN) for all the rail types currently under evaluation.

TEST SETUP

Test rail strings were welded at a CN plant in Winnipeg prior to installation. Figure 1 illustrates the test string layout.



Figure 1. Test rail string layout

Each string has three 40-foot lengths of each vendor's test rail distributed evenly throughout the curve. Additionally, seven CN control rail sections were evenly distributed among the test strings. For consistency, each vendor rail was placed adjacent to a CN control rail at least once. The same layout pattern was used for both the high and low rail.

Measurement Layout

TTCI engineers identified and labeled approximately 254 locations in the test curve for measurement. The locations were distributed along the test curve and included all seven types of rail. Measurements and observations at each location included cross-sectional rail profiles collected with a digital profilometer, a qualitative evaluation of rolling contact fatigue, and visual documentation via photograph. Figure 2 shows measurement locations for each stick of rail.

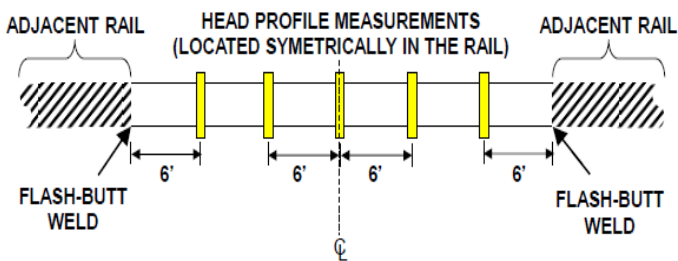


Figure 2. Measurement layout in each 40-foot rail test rail segment

EARLY ROLLING CONTACT FATIGUE ISSUES

Following installation of the test rail strings, moderate to severe RCF developed throughout the test curve during accumulation of the first approximately 60 MGT. If not properly addressed, rail RCF can decrease the lifespan of rails significantly.

The team analyzed the RCF severity using a qualitative method of severity evaluation developed by TTCI.¹ This evaluation is judged on a scale from 0.0 to 3.0 with 0.0 representing no RCF development and 3.0 being severe RCF development. The results showed that all of the test rails developed less RCF, in general, than the control rail on the high rail of the curve. However, three vendor rail types developed more severe RCF than the control rail on the low side of the curve. Figure 3 shows the results of this analysis.²

Initial analysis indicated that a likely cause of RCF was improper gage face lubrication throughout the test curve. Following corrective grinding of both low and high rails and adjustments to the nearby lubricator units, inspections have shown only minor RCF development. Figures 4 and 5 illustrate the difference in RCF seen at the test site between initial and subsequent inspections.

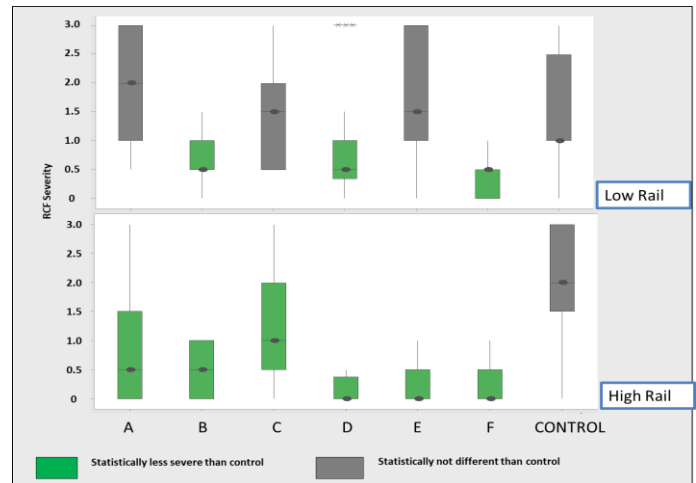


Figure 3. RCF severity for all rail types at 60 MGT



Figure 4. RCF, location No. 28 on low rail during April 2016 inspection



Figure 5. Location No. 28 on low rail during May 2019 inspection

ANALYSIS OF RAIL WEAR

To evaluate performance of the various rail types, TTCI performed a statistical analysis of gage face wear and total area loss by rail type. These two parameters provide a good overall view of rail performance characteristics and potential lifespan when compared with typical rail wear maintenance limits. This analysis was performed on measurement data gathered during 12 different inspection cycles during which approximately 219 MGT were accumulated across the test curve. All available data from the 254 measurement locations was included in the analysis.

Analysis of Variance (ANOVA), a standard statistical test used to compare multiple mean values, was used to compare the mean rail wear of each rail type. Analysis was conducted to ensure the assumptions of the data by the ANOVA test were met. The test showed a statistically significant difference in the means of the rail wear, using a 95 percent confidence level. This finding indicates that there is a statistically significant difference between the performances in the rails as measured by its mean rail wear.

A post hoc test was conducted to compare the means to each other to determine which performed differently. Figures 6 and 7 show that rail types B, C, and E have the least rail wear overall.

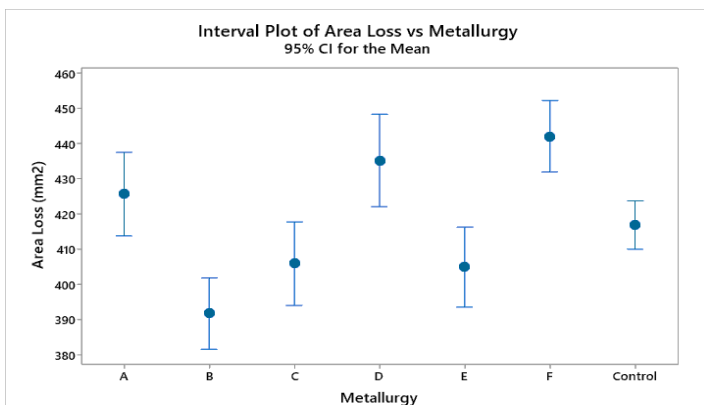


Figure 6. Low rail total area loss by vendor type

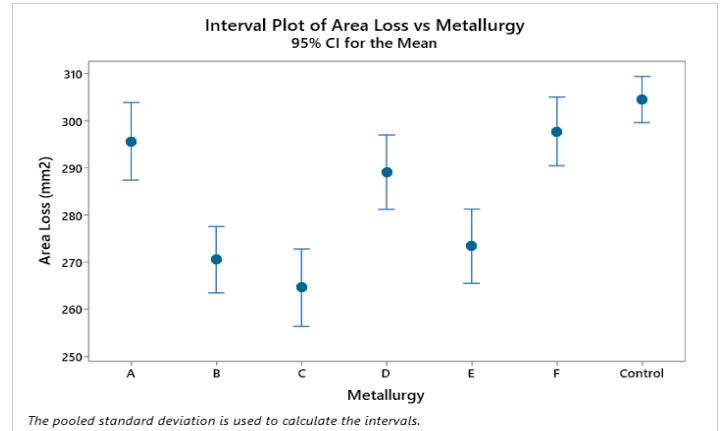


Figure 7. High rail total area loss by vendor type

RAIL HARDNESS ANALYSIS

Testing at the Facility for Accelerated Service Testing (FAST) near Pueblo, CO has shown that rail hardness is directly related to wear.³ The results for testing at the northern mega site (Figure 8) shows a similar trend—rails with higher hardnesses generally wear less. The data however does not appear to correlate fully with past findings as there are outliers where the inverse appears to be true; i.e., rails with higher hardness have actually worn more. Figure 8 shows average area loss which includes grinding loss and natural rail wear. The weak correlation between hardness and area loss is possibly because natural wear was not separated from total area loss as measurements were not collected immediately before and after grinding. At FAST, rail wear data is collected before and after grinding with no tonnage accumulation in between to separate natural rail wear from area loss from grinding.

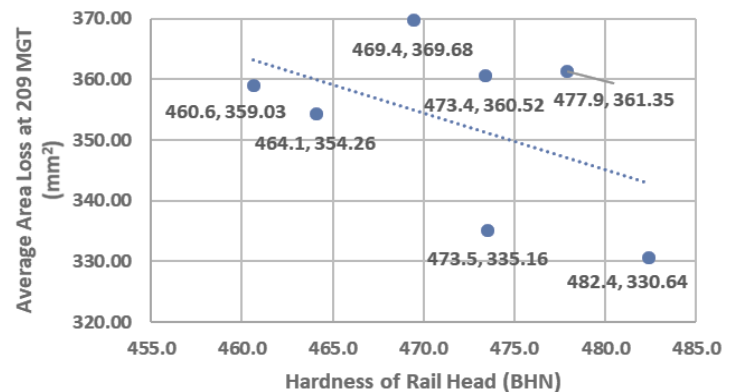


Figure 8. Brinell hardness versus average total area loss by rail type

PREMATURE RAIL FAILURES

To date, no cases of in-service rail failure have occurred in the test curve rails. A single electric flash butt weld made during the original assembly of the test strings was marked defective during an ultrasonic rail inspection and subsequently was removed relatively early in the test. The replacement of the defective weld with a rail plug resulted in the removal of some measurement location. It also introduced two thermite welds into the test curve on the low rail. There are currently no other thermite welds in the test curve.

No additional electric flash butt welds have been marked as defective or removed as of the most recent inspection in May 2019. However, several have started to exhibit rail battering. It is to be noted that these flash butt welds made using the test rails were not air quenched to achieve extra strength and hardness of the welds. Figure 9 shows an example of this weld degradation.



Figure 9. Rail batter development on electric flash butt weld

Engineering forces have begun planning to replace a stretch of the low rail to remediate battered welds that are nearing the CN maintenance limits.

SUMMARY

TTCI engineers continue to monitor the test curve located in western Ontario on the CN railway network. Data collected through approximately 219 MGT of accumulated tonnage has begun to show some separation in the wear characteristics of the different vendor rails, with three rail types showing statistically less wear than the others.

Early issues with RCF appear to have been addressed with grinding and adjustment to lubrication of the curve. Only one premature failure has been documented in the test area, and this was a defective electric flash butt weld.

References

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2. Joy, R., K. Ninness, J. Baillargeon, and D. Voelkerding. May 2017, "Testing on the Heavy Axle Load Northern Mega Sites." *Technology Digest* TD17-009. AAR/TTCI Pueblo, CO.
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