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# Update on Mega Site Rail Life Extension Performance Testing

Kyle Ninness and Gary Fry (TTCI), Steve Lakata and Brad Kerchof (NS),
Chris Rewczuk (UP), and Jay Baillargeon (FRA)

## Summary

Rail life extension strategies aim to further increase the service life of rails under mainline heavy axle load (HAL) operations. In 2013, Transportation Technology Center, Inc. (TTCI), in collaboration with host railroads, initiated two new experiments at the revenue service mega sites to investigate rail life extension strategies on the latest generation rails in the revenue service environment. Thus far, preliminary results have shown the following:

- With 429 million gross tons (MGT) accumulated at the western mega site, it is still too early to differentiate between the performance of two 2-degree test curves, one with an "optimized" maintenance strategy (friction control plus preventive grinding once every 150-190 MGT) and the other being the control (no friction control, nor preventive grinding).
  - There was a 50 percent decrease in rail wear for similar tonnage compared to the 2005 rail test.
  - Significant rolling contact fatigue (RCF) on the low rails began to appear at 350 MGT for both the 2013 and 2005 test rails.
- At the eastern mega site, three sharp test curves (9-11 degrees) have been established with friction modifier and gage-face lubrication. Optimized grinding cycles have been implemented in one high-strength rail test curve and in the intermediate-strength rail test curve. The other high-strength rail curve is the control without grinding scheduled until significant RCF occurs. With 92 MGT accumulated to date, the results have shown:
  - The intermediate-strength rail test curve has required a more aggressive maintenance grinding schedule than the high-strength rail test curve to keep up with the higher rate of RCF development.
  - All three curves received a re-profiling grind after 90 MGT to address the degradation of the wheel/rail contact interface.
  - The high-strength rail test curves are performing well compared to the intermediate-strength rail test curve, presenting less rail wear and a lower rate of RCF development.
  - Rail wear is near equal for high-strength rails compared to the 2005 rail test.

This investigation is being conducted under the HAL revenue service program cosponsored by the Association of American Railroads and Federal Railroad Administration.

Please contact **Gary Fry (719) 584-0641** with questions or concerns regarding this *Technology Digest.* E-mail: gary_fry@aar.com.

## INTRODUCTION

TTCI, through its efforts under the jointly funded HAL Revenue Service Testing Program, continues to drive leading-edge research in the area of improved rail wear performance and fatigue resistance by way of rigorous in-track evaluation of the latest high-strength rail steels and advanced rail life extension strategies.

Results from previous long-term studies of high-strength rail performance with rail life extension strategies, such as top-of-rail (TOR) friction modifier, have provided valuable insight into the benefits such strategies can have on the service life of rail in curves. Among the most influential of these benefits in terms of extending rail life are improved resistance to wear, reduction in the severity and delay in the development of rolling contact fatigue (RCF).

Building upon the information provided from previous testing efforts at the mega sites,[1] TTCI, in collaboration with Union Pacific (UP) Railroad and Norfolk Southern (NS) Railway, have installed new test curves at both the eastern and western mega sites to (1) evaluate the latest generation of high-strength rail steels currently available to the industry, comparing their performance against that of the previous generation tested, and (2) optimize rail life extension strategies for both high- and intermediate-strength rails based on the results provided by the previous revenue service testing at the mega sites. This *Technology Digest* reports on the initial results taken from this new phase of testing at both mega sites.

## NEW RAIL TESTS AT THE MEGA SITES

The western mega site is located on a 120-mile stretch of UP main line in western Nebraska. This heavy-haul coal route sees between 180 and 220 million gross tons (MGT) of traffic annually from 36-ton axle loads with operating speeds ranging between 40 and 50 mph over near-flat grades (Table 1).

**Table 1: Summary of Operating Conditions at the Mega Sites**

| | Curvature | | |
|---|---|---|---|
| | 2-degree | 9.7-degree | 11.3-degree |
| Operating Speed (mph) | 40-50 | 15-25 | 15-25 |
| Balance Speed (mph) | 53 | 19 | 19 |
| Superelevation (in) | 4.0 | 2.5 | 3.0 |

New rail testing in this revenue service location began in fall 2013 on two 2-degree curves with standard concrete ties and fasteners. Four grades of high-strength rail from four manufacturers were represented: ArcelorMittal U.S., EVRAZ Rocky Mountain Steel, Nippon Steel & Sumitomo Metal, and Mitsui USA/JFE Steel. One curve was considered the control, with only gage-face lubrication for the initial phase. The control curve allows a comparison of the performance of the latest and previous generations of rail at the western mega site.[3] The second curve, with gage-face lubrication, implemented TOR friction modifier from the beginning, as well as preventive grinding on an optimized schedule of every 150 to 190 MGT (approximately once per year), based on the previous studies.[1,2,3]

The eastern mega site is located on a major NS heavy haul coal route through the mountains of West Virginia. This line typically sees approximately 45 MGT of 36-ton axle load traffic annually, operating at speeds between 15 and 25 mph over grades as steep as 1.4 percent. Hardwood ties and a mixture of cut spikes and elastic fasteners are used throughout this site. Six grades of high-strength rail were installed in two 11.3-degree curves in spring 2014 from five domestic and international manufacturers: ArcelorMittal U.S., EVRAZ Rocky Mountain Steel, Nippon Steel & Sumitomo Metal, Mitsui USA/JFE Steel, and TATA Steel. Given the higher degree of curvature, one curve, considered to be the control, began testing with gage-face lubrication and TOR friction modifier. This curve provides the means of comparing this latest generation of high-strength rails with that of the previous generation. The second curve includes gage-face lubrication, TOR friction control, and preventive grinding on an optimized schedule of every 45 MGT (approximately once per year).[3,4]

Investigation into the benefits of this optimized rail life extension strategy has been extended to an additional test curve within the eastern mega site (with 9.7 degrees of curvature) featuring five grades of intermediate-strength rail from five manufacturers: ArcelorMittal U.S.; EVRAZ Rocky Mountain Steel; Lucchini; Steel Dynamics, Inc.; and Třinecké železárny/Moravia Steel Group. This will allow TTCI to evaluate the performance of this optimized strategy for intermediate-strength rails in high degrees of curvature.

## RESULTS FROM THE WESTERN MEGA SITE

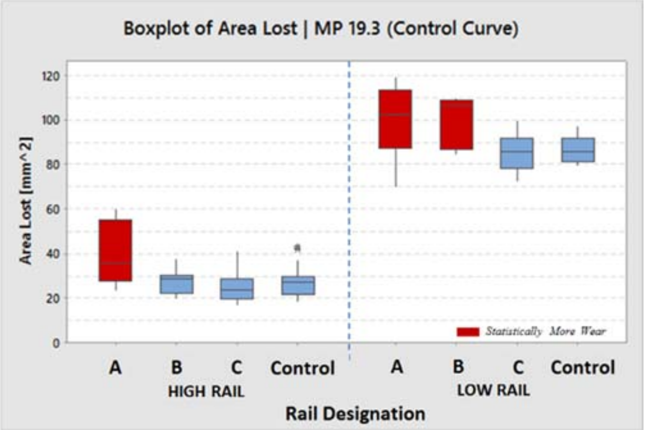
To date, the western mega site has accumulated 429 MGT. During inspection and measurements at 271 MGT, minor RCF in the form of spalling began to appear at several locations within both curves. Grinding was initiated at 272 MGT to address the RCF, and to place the test curve with TOR friction control on a regular grinding regimen of approximately once per year to address further RCF that may develop. At 350 MGT, both curves were developing significant RCF on the low rail, which was similar to the 2005 high-strength rail test. A corrective grinding cycle was performed on both low rails to address the problem. Currently, after an additional 80 MGT since the corrective grinding, the condition of the running surface of the low rail appears to have significantly improved.

Figure 1 shows the wear for the test curve compared to the control curve. The amount of rail wear throughout both curves is very similar despite the presence of TOR friction modifier in the test curve. The cause of the equivalent rail wear with and without the presence of friction modifier is being further explored to account for the minimal effect at this location.

Previously, in the 2005 high-strength rail test, rail wear was significantly decreased with the use of TOR friction modifier.[1] The high rail of the test curve had slightly more railhead area loss than the control curve, largely due to the area loss from the first grinding cycle at 272 MGT.

The control rail has a known performance, and it was also used as the control rail for the 2005 test. Rail A was the only rail that demonstrated statistically higher wear than the control rail at all test locations (Figure 1). In Figure 1, red indicates statistically more wear than the control rail in the test zone.

Both curves have more area lost in the low rail than in the high rail, and the low rail area loss is comparable for both curves. This is a similar wear pattern to what was observed in 2005 rail tests; however, the area loss of the new high-strength rail is less than 50 percent of the rail wear from the 2005 test with similar tonnage.



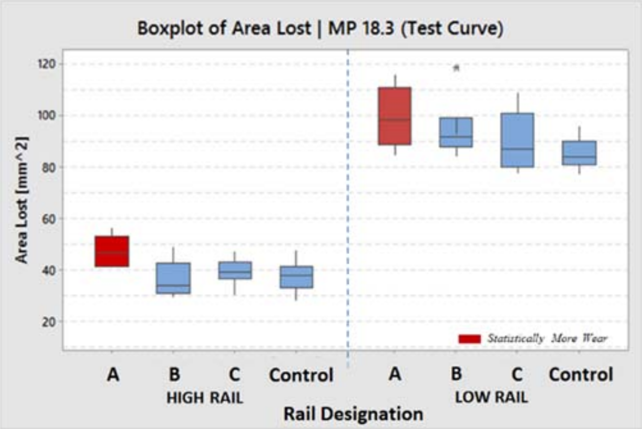


**Figure 1. 2013 Rail wear results at the western mega site**

## RESULTS FROM THE EASTERN MEGA SITE

The eastern mega site has accumulated 92 MGT up to the most recent measurement cycle. The optimized grinding cycles were originally proposed for once per year. However, after just 31 MGT on the intermediate-strength rail curve, the team decided to start grinding twice a year – roughly every 23 MGT, which is normal frequency for this line. Thus far, the intermediate-strength rail curve has received three grind cycles, where spalling was removed and the rail was re-profiled.

The high-strength rail test curve did not receive its first grind until 45.5 MGT, and it will continue to receive preventive grinding every 40-50 MGT. In March 2016, all three test curves received a re-profiling grind to modify the wheel/rail contact interface. To date, the high-strength rail test curve has only received two grinding cycles.

The test rail within the 2014 high-strength rail curves appears to be in good condition; however, minor spalling toward the field side of the railhead was observed within this curve. The recent re-profiling grind addressed this issue and restored proper wheel/rail contact. Post-grind inspection of both curves revealed that the running band returned to the center of the railhead, suggesting better wheel/rail contact with the current profile. The curve that uses the grinding cycle of once every 40-50 MGT is performing well, with only minor head checking on both the high and low rails.

The box plots in Figure 2 indicate red if the test rail has worn statistically more than the control rail, and green if it has statistically less wear than the control rail. The control rail (*) was selected for its known performance and historical data from the 2005 rail test.

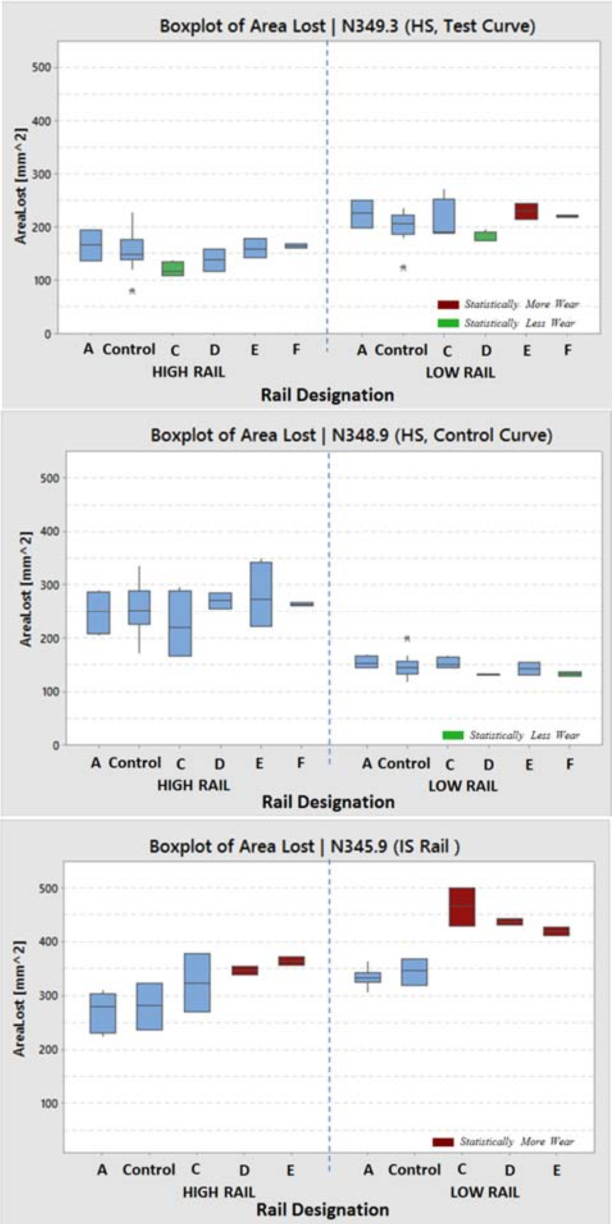


**Figure 2: Rail wear results at the eastern mega site**

During the most recent pre-grind inspection of the intermediate-strength rail curve, head checking as well as areas of severe spalling were observed throughout the low rails. In particular, Rails C, D, and E have had worse spalling and head checking than Rails A and B, and have a higher rate of rail wear, as well.

Note that the rail metallurgy for these three rails is intermediate hardness (minimum 325 BHN) compared to rails A and B, which have a 350 BHN. This difference in rail hardness likely accounts for the notable difference in performance within the 9.5-degree curve. The current grinding schedule for the intermediate-strength rail curve may still not be frequent enough to prevent RCF from progressing.

## FUTURE WORK

Twice-annual measurements and inspection of the eastern and western mega site test zones will continue throughout the life of the rail. Optimized grinding cycles, once per annum, will continue at both mega sites, with corrective grinding when deemed necessary. Further wear results and the effectiveness of rail life extension methodologies will be reported in future *Technology Digests.*

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