U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 19-08 | **April** 2019

RAIL INTEGRITY AND INITIAL PERFORMANCE TESTING AT THE MEGA SITES

SUMMARY

The Federal Railroad Administration (FRA) with the Association of American Railroads (AAR) co-sponsored rail integrity and performance testing as part of the joint Heavy-Axle-Load (HAL) Revenue Service Program. Transportation Technology Center, Inc. (TTCI) investigated the performance of improved rail alloys, curve lubrication practices, and grinding practices in revenue service at the eastern and western mega sites located near Bluefield, WV, and Ogallala, NE, respectively. The testing and evaluation began in 2005 and concluded in 2017. This report serves as the final update for those tests.

The test zone at the western mega site was comprised of one 1-degree curve and two 2-degree curves. These curves supported 200–250 million gross tons (MGT) of traffic annually under operating speeds ranging between 40 and 50 mph over near-flat grades. The track structure is comprised of concrete ties with elastic fasteners. Figure 1 shows a photograph of one of those test curves.

Figure 1. Test curve at the western mega site.

The test zone at the eastern mega site was comprised of two 6.8-degree curves and two 10-degree curves. These curves supported an estimated 55 MGT of traffic annually, under operating speeds ranging between 15 and 25 mph over grades as steep as 1.4 percent. The track structure was comprised of timber ties with cut spikes. Figure 2 shows a photograph of one of those test curves.

Figure 2. Test curve at the eastern mega site.

The results obtained from testing at the mega sites include the following:

- Over the testing period, more than 2,200 MGT was accumulated at the western mega site and more than 500 MGT at the eastern mega site.
- No internal rail defects were reported to TTCI over the period of testing.
- Only intermittent rolling contact fatigue (RCF) growth was detected after approximately 1,000 MGT. There was also a statistically significant reduction in the rate of wear for both high and low rails in one of the 2-degree curves at the western

mega site, following the implementation of top-of-rail (TOR) friction modifier.

BACKGROUND

In the fall of 2005, TTCI began tests of high-performance rail at the eastern and western mega sites, located near Bluefield, WV, and Ogallala, NE, respectively. The scope of testing in revenue service included an evaluation of gage-face lubrication, TOR friction modifier, and corrective or preventative grinding practices. The tests included eight premium rail grades from six manufacturers: EVRAZ Rocky Mountain Steel, ArcelorMittal U.S., Nippon Steel & Sumitomo Metal, Mitsui USA/JFE Steel, voestalpine Steel, and British Steel (formerly TATA Steel). This program of testing concluded in 2017.

OBJECTIVES

Rail integrity and performance testing have been integral to the HAL revenue service testing at the western and eastern mega sites since 2005. The initial objective of this testing at the mega sites was to supplement the testing at the Transportation Technology Center in Pueblo, CO, in order to provide more diverse operating and climatic conditions when investigating the performance of premium rails available to the industry. Starting in 2008, the scope of testing was extended to include rail maintenance strategies, namely gage-face (GF) lubrication, TOR friction modifier, and preventative grinding practices.

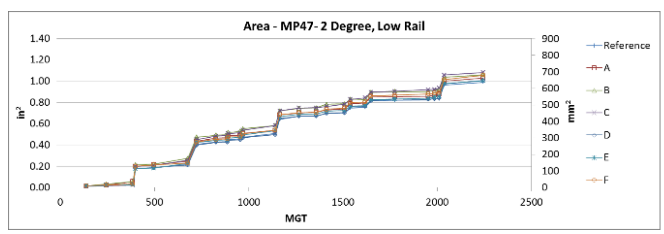
TEST SITES

The test zone on the western mega site, located on the Union Pacific Railroad's (UP) South Morrill Subdivision, had three different test curves: one 1-degree curve and two 2-degree curves. These curves supported 200–250 MGT of traffic annually under operating speeds ranging between 40 and 50 mph over near-flat grades. The track structure is comprised of concrete ties with elastic fasteners.

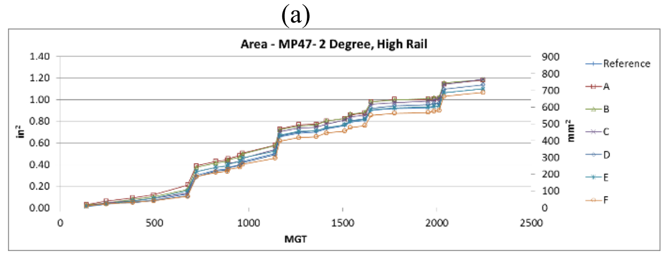
The test zone on the eastern mega site, located on Norfolk Southern Railway's (NS) Virginia Division, had four different test curves: two 6.8-degree curves and two 10-degree curves. These curves supported an estimated 55 MGT of traffic annually, under operating speeds ranging between 15 and 25 mph over grades as steep as 1.4 percent in some areas. The track structure was comprised timber ties with cut spikes.

RESULTS

The premium rails installed in the test curves at the western mega site accumulated more than 2,200 MGT of traffic at the conclusion of the test and no internal rail defects were reported to TTCI over the period of testing. In 2008, the subject of this testing shifted from strictly rail performance to the evaluation of rail maintenance strategies using two different methods to control RCF growth and railhead wear rates. Figure 3a and 3b are plots of the total railhead area lost in one of the 2-degree test curves on the western mega site: 3a low rail; 3b high rail.



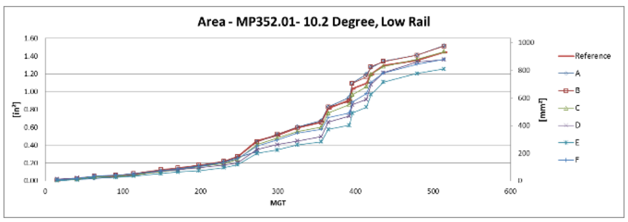
(a)



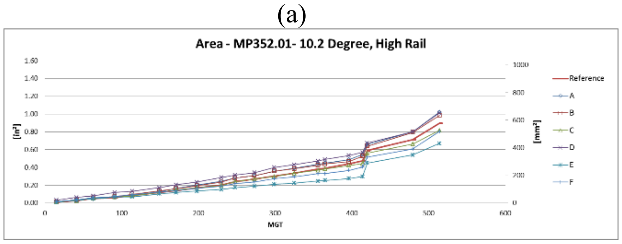
(b)

Figure 3. Total railhead area lost at conclusion of western mega site premium rail tests: (a) low rail; (b) high rail.

With more than 500 MGT accumulated at the conclusion of the test, the premium test rails within the eastern mega site showed resistance to internal fatigue; like the western mega site, no internal rail defects were reported to TTCI over the period of testing. Due to the higher degree of curvatures, GF lubrication and TOR friction modifier was used at each of the four test curves since the initiation of the test in 2005. Corrective grinding was implemented on three separate occasions to remove RCF and plastic flow during the course of testing. Figure 4a and 4b are plots of the total railhead area lost in one of the 10-degree test curves on the eastern mega site: 4a low rail; 4b high rail.



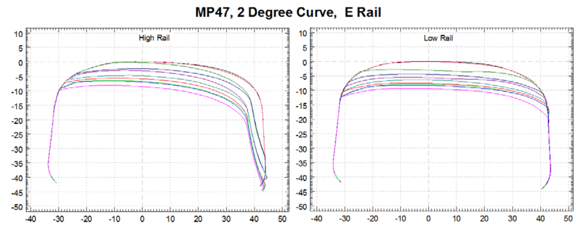
(a)



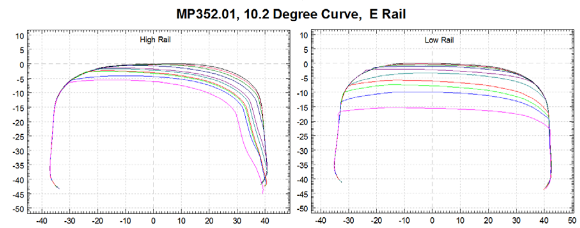
(b)

Figure 4. Total railhead area lost at conclusion of eastern mega site premium rail tests: (a) low rail; (b) high rail.

Figure 5a shows the gradual change in rail profiles of Type E rail in the western mega site while Figure 5b shows the same for Type E rail in the eastern mega site. The profiles shown in different colors indicate profiles measured at different MGT intervals. At both mega sites, the high rail wear consisted of primarily gage face and gage corner wear while the low rail had head wear as the main wear mechanism.



(a)



(b)

Figure 5. Rail profiles of Type E rail from both high and low rails as measured at the (a) western mega site and (b) eastern mega site

CONCLUSIONS

- Over the testing period, more than 2,200 MGT accumulated at the western mega site and more than 500 MGT at the eastern mega site.
- In both locations, no internal rail defects were reported to TTCI over the period of testing.
- Only intermittent RCF growth was detected after approximately 1,000 MGT.
- There was a statistically significant reduction in the rate of wear for both high and low rails in one 2-degree curve at the western mega site, following the implementation of TOR friction modifier.
- The low rail received the most benefit from the application of TOR friction modifier, which showed a reduction in the median rate of wear from 0.01 in^2 to 0.004 in^2 per 100 MGT.

Without friction control or grinding, the 1-degree test curve developed moderate, yet isolated, areas of RCF after approximately 960 MGT. Corrective grinding was implemented following this discovery. The rail was later removed at 1,782 MGT due to severe, sporadic spalling.

REFERENCES

1. Li, D., Atkinson, S., and McDaniel, R. February 2008. "Interim Performance Results of Premium Rails in Revenue Service at Mega Sites." *Technology Digest* TD-08-008. AAR, TTCI, Pueblo, CO.
2. Li, D., Gutscher, D., and Maal, L. September 2011. "Prevention of rail rolling contact fatigue under heavy-axle-loads." *Railway Track & Structures*, *107*(9), pp. 16–18. Chicago, IL.
3. Li, D. et al. June 2011. "Recent Advances in Rail Life Extension in North American Heavy Haul Railways." *Proceedings of the International Heavy Haul Conference*, Calgary, Canada.
4. Reiff, R., Conn, K, and Li, D. March 2006. "East Mega Site Wayside Top of Rail Friction Control Implementation Status." *Technology Digest* TD-06-006. AAR, TTCI, Pueblo, CO.
5. Baillargeon, J., Gutscher, D., and Li, D. May 2014. "Premium Rail Performance and Rail Life Extension at the Mega Sites." *Technology Digest* TD-14-005. AAR, TTCI, Pueblo, CO.

ACKNOWLEDGEMENTS

TTCI conducted this research under a joint effort with FRA and the AAR HAL Revenue Service Program. TTCI researchers who contributed significantly to this work included Jay Baillargeon (formerly of TTCI), Daniel Gutscher, Megan Brice, and Dingqing Li. TTCI acknowledges Evraz Rocky Mountain Steel, ArcelorMittal U.S., Nippon Steel & Sumitomo Steel, Mitsui USA/JFE Steel, voestalpine Steel, and British Steel (formerly TATA Steel) for their generous donation of rails. Finally, TTCI gratefully acknowledges the revenue service site hosts for their unwavering support of revenue service testing: NS and UP.

CONTACT

Jay Baillargeon
Program Manager
Federal Railroad Administration
Office of Research, Development and Technology
55500 DOT Road
Pueblo, CO 81001
(719) 584-7155
jay.baillargeon@dot.gov

Gary Carr
Chief – Track Research Division
Federal Railroad Administration
Office of Research, Development and Technology
1200 New Jersey Avenue, SE
Washington, DC 20590
(202) 493-6354
gary.carr@dot.gov

KEYWORDS

Rail, rolling contact fatigue, RCF, wear, friction control, grinding, mega site