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Rail Life Extension through Friction Control and Grinding

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Summary

A long-term heavy axle load (HAL) revenue service test conducted by the Transportation Technology Center, Inc. has shown that head-hardened premium rails perform well in resisting wear from traffic and internal fatigue growth, but occurrences of rolling contact fatigue (RCF) can be significant. If not removed, RCF on the rail surface may hinder automated rail flaw detection and may reduce rail life. The following are the main findings regarding RCF and its prevention from this test:

- Occurrences of RCF depend on curvature. At the eastern mega site, with top of rail (TOR) friction control, RCF started to appear after about 250 MGT for the 10.5-degree curves and after 300 MGT for the 6.8-degree curves. At the western mega site (without TOR friction control), RCF started to occur after 300 MGT for the 2-degree curves and after 1,000 MGT for the 1-degree curve.
- RCF occurred earlier on low rails than on high rails, primarily because of trains running below the balance speeds at both mega sites. For example, at the eastern mega site, RCF has not occurred on the high rails after more than 300 MGT. At the western mega site, RCF did not occur until 570 MGT for the high rails in the 2-degree curves.
- TOR friction control can delay or prevent occurrences of RCF. At the western mega site, as a result of implementing TOR friction control, the same 2-degree curve has not shown RCF after more than 700 MGT following a corrective grinding to remove RCF.
- Preventive grinding is an effective strategy to prevent RCF and is better than corrective grinding because, cumulatively, preventive grinding, when planned properly, causes less metal removal than corrective grinding.
- As a result of using premium rails in combination with friction control and preventive grinding, rail wear life can be extended at least two times as long, if roughly compared to the average rail service life for the similar track curvature groups.

This revenue service rail test is conducted at the eastern and western mega sites, located in Bluefield, West Virginia, and Ogallala, Nebraska, respectively. The four test curves at the eastern mega site are from 6.8 to 10.5 degrees and are subjected to approximately 55 MGT of HAL traffic a year. The three test curves at the western mega site have curvatures of 1 and 2 degrees, and are subjected to approximately 250 MGT of HAL traffic a year. This test is jointly funded by the Association of American Railroads and the Federal Railroad Administration, under the revenue service mega site testing program.



INTRODUCTION

The Association of American Railroads and Federal Railroad Administration jointly fund a HAL revenue service testing program, which has been ongoing since 2005. A number of experiments have been completed, addressing issues related to track infrastructure under HAL operations. There are also several long-term experiments, including the premium rail performance test, which was initiated in September 2005, to monitor the performance of a number of new head-hardened premium rails under two different HAL operating environments: one in the east with Norfolk Southern Railway (NS), and the other in the west with Union Pacific Railroad (UP).

Test results have shown that all premium rails have excellent performance in terms of resisting wear from traffic and internal fatigue growth.¹ However, RCF occurrences were significant for all premium rails tested. If not prevented or removed, RCF on the rail surface obstructs automated detection of internal rail flaws and may shorten rail service life. Figure 1 shows RCF conditions that appeared on the test rails installed at the western mega site.



Figure 1. RCF on Head-hardened Premium Rails

Since September 2008, this rail performance test has included another objective to monitor the effectiveness of TOR friction control and grinding operations (corrective versus preventive grindings). This *Technology Digest* summarizes the findings to date.

RAIL TEST IN REVENUE SERVICE

At the eastern mega site, eight premium rail types from four suppliers were installed in four curves (two 6.8-degree curves and two 10.5-degree curves). Trains operate through the curves between 20-30 mph, and tonnage is accumulated at approximately 55 MGT per year. The track has timber ties with cut spikes.

At the western mega site, seven premium rail types from six suppliers were installed in three curves (one 1-degree curve

and two 2-degree curves). Trains operate through the curves at 40-50 mph, and tonnage is accumulated at approximately 250 MGT per year. The track has concrete ties with elastic fasteners

Figure 2 shows the history of the rail test conducted in the eastern and western mega sites since September 2005. For the four test curves at the eastern mega site, a total of 310 MGT has accumulated. For the three test curves at the western mega site, a total of 1,400 MGT has accumulated.

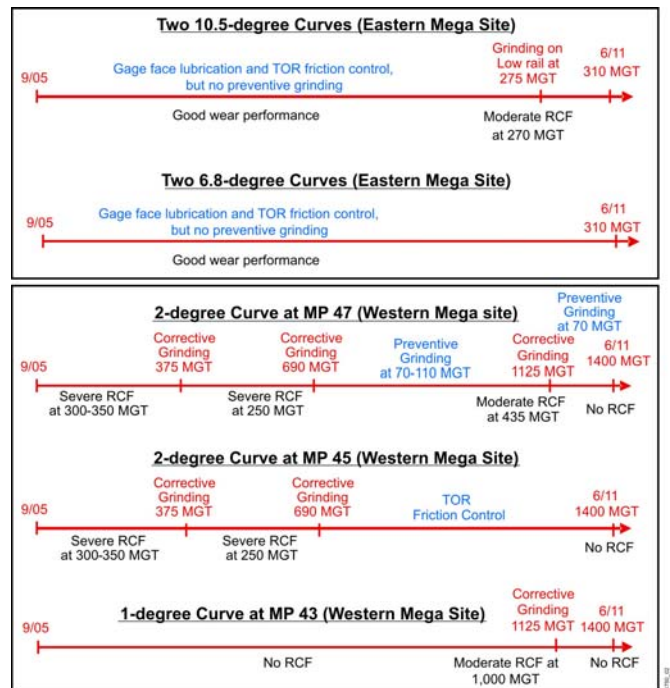


Figure 2. Rail Test at Eastern and Western Mega Site

TEST RESULTS AT EASTERN MEGA SITE

At the eastern mega site, all four curves have been implemented with gage face lubrication and TOR friction control from the beginning of the experiment. For more than 300 MGT, all premium test rails have shown excellent wear performance (see Figure 3 for a 10.5-degree curve). For instance, at 275 MGT, average total wear from traffic was only 4.6 percent of the railhead area, and the average wear rate was only 0.09 in²/100 MGT.

No internal defects have been identified to date, and rail surface condition has been good until 250 MGT, when moderate RCF started to appear only on low rails of 10.5-degree test curves. Grinding was performed at 275 MGT to remove RCF. Figure 3 (top graph for the low rails) shows the amount of rail steel removed from grinding. (Note: Normally NS grinds rail in the area approximately every 30 MGT.)

The average rail wear life (including the loss of rail steel from grinding) was projected to be 800 MGT for a 10.5-degree curve (allowing 20 percent of railhead area loss) and 2,000 MGT for a 6.8-degree curve. As a rough comparison, these are significantly higher than the average rail service life for similar curvatures

(400 and 500 MGT, respectively), based on a survey conducted in 2008.² To a large degree, implementation of gage face lubrication and TOR friction control has contributed to the excellent performance of the premium test rails.

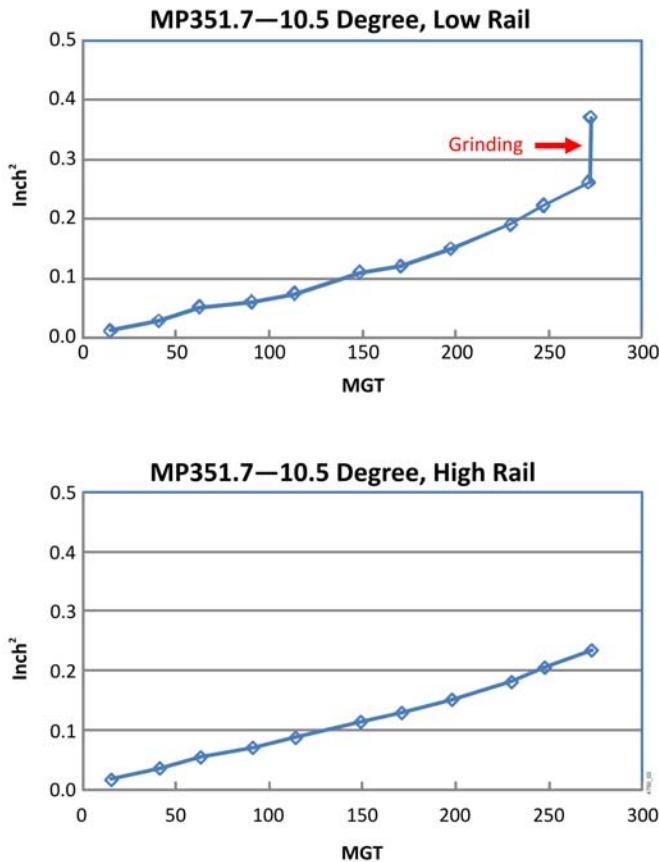


Figure 3. Average Rail Wear from Traffic and Grinding (Eastern Mega Site)

In another experiment conducted at the eastern mega site, the performance of nonpremium rails was monitored in two groups of curves. Each group has six curves with various curvatures and rails of mixed types and ages. One group was implemented with gage face lubrication and TOR friction control, whereas the other group was only implemented with gage face lubrication. Since 2007, data has shown that implementation of TOR friction control reduced vertical wear by approximately 30 percent. In addition, TOR friction control reduced loss of rail steel from grinding operations, suggesting that TOR friction control reduced the occurrence of RCF.²

TEST RESULTS AT WESTERN MEGA SITE

At the western mega site, all premium test rails have also shown excellent wear performance. No internal defects have been identified to date after 1,400 MGT. However, RCF developed on the 2-degree curves, mainly on the low rails, after 300 to 350 MGT. (Note: normally UP grinds rail in the area approximately every 60 MGT.) A corrective grinding was conducted to remove RCF, but 270 to 300 MGT later, RCF developed again, which required a second corrective grinding in September 2008. When the second corrective grinding was needed for the low rails, the

high rails had also developed RCF and required a corrective grinding as well (see Figure 2 for various activities for the test curves).

Figure 4 shows the amount of rail wear from traffic and grindings for the two 2-degree curves. As illustrated, the amount of rail wear from traffic was insignificant compared to the loss of rail from grindings. In fact, a corrective grinding removed more rail steel than 1,300 MGT of traffic did.

In September 2008, as part of the rail life extension research, the UP started implementing two different methods to address the RCF problems. In one 2-degree curve, TOR friction control was implemented and in another 2-degree curve, preventive grinding was scheduled every 70 MGT, as determined from earlier modeling.² To date, more than 700 additional MGT have accumulated, and little RCF has been observed on the curve with TOR friction control and only some RCF was observed in the other curve when a preventive grinding was late (at 110 MGT, rather than at 70 MGT recommended).

Figure 4 includes the amount of rail loss from each grinding cycle. On average, each preventive grinding cycle removed less than 0.02 in² of rail, roughly equivalent to the wear from 150 MGT of traffic. As a comparison, a corrective grinding cycle removed close to 0.2 in² of rail steel in order to remove the RCF damage.

Based on the test results shown in Figure 4, the projected rail wear life is 4,000 MGT for the 2-degree curve with TOR friction control, and 2,200 MGT for the curve with service scheduled preventive grinding. As a rough comparison, the average rail life for 2-degree curves is 950 MGT.²

For the 1-degree curve, because RCF did not occur until after 1,000 MGT, no TOR friction control or preventive grinding was implemented in this curve (see Figure 2).

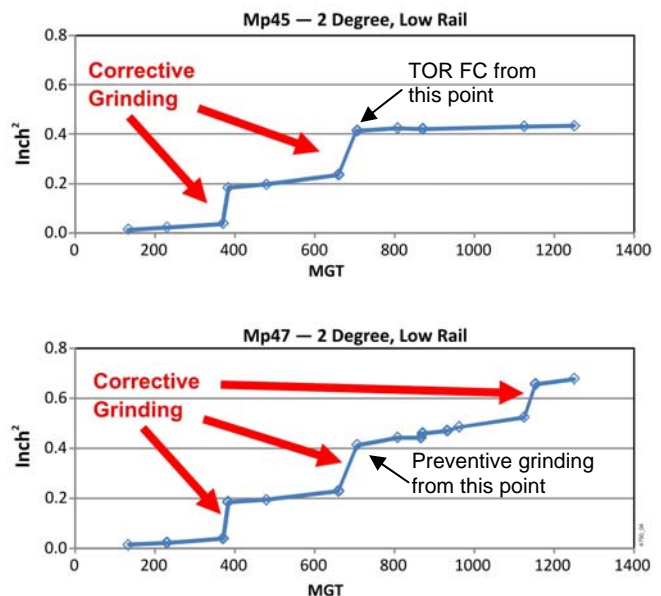


Figure 4. Average Rail Wear from Traffic and Grinding (Western Mega Site)

Figure 5 shows the spread of test results among seven rail types tested at the western mega site. For 2-degree curves, the spread of wear performance was less than 20 percent. In addition, the spread of wear performance for the 10.5-degree test curves at the eastern mega site was approximately 30 percent.

In Figure 5, as expected, natural rail wear from traffic was larger on high rails than on low rails; however, for either curve at MP 45 or MP 47, the total wear from traffic and grinding was similar between high and low rails.

For the curve with TOR friction control (MP 45), the total wear is significantly lower than the curve with scheduled preventive grinding (MP 47). That is why projected rail wear life is higher for the curve with TOR friction control. However, this test is yet to be complete because it is unknown when RCF will occur again in the curve with TOR friction control.

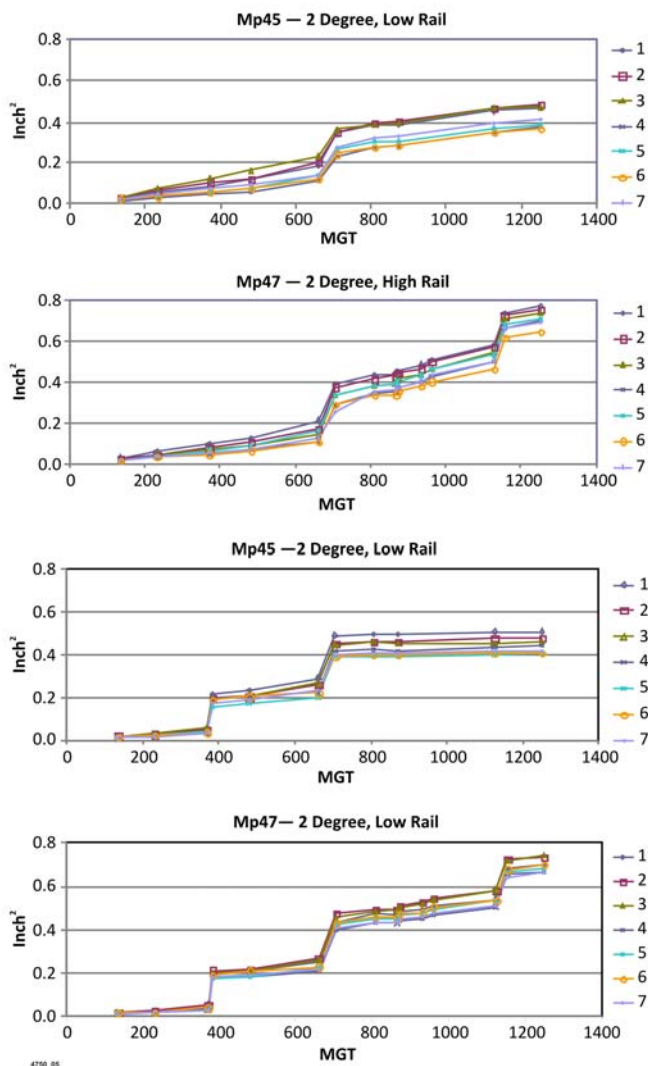


Figure 5. Rail Wear Test Results for All Test Rails (Western Mega Site)

Table 1 summarizes the wear or wear rates for all test curves at the mega sites from four different conditions.

Table 1. Rail Wear Rate

Curvature (degree)	Traffic Only	Traffic & TOR FC	Preventive Grinding	Corrective Grinding
1	0.01 in ² /100 MGT	n/a	n/a	
2	0.02 in ² /100 MGT	0.01 in ² /100 MGT	0.015 in ²	0.16 in ²
6.8	n/a	0.04 in ² /100 MGT	n/a	
10.5	n/a	0.10 in ² /100 MGT	n/a	0.11 in ²

CONCLUSION

Performance monitoring of these rail test curves at both mega sites continues. With more test data, a cost benefit analysis will be performed between TOR friction control and preventive grinding implemented to prevent/delay occurrences of RCF. The following are the results to date:

- Premium rails have shown excellent performance in resisting wear from traffic and internal fatigue growth
- RCF occurrences were significant and often appeared on low rails first, mainly because of trains running below the balanced speeds. In addition, RCF occurrences were directly related to track curvature
- TOR friction control can greatly reduce occurrence of RCF and also wear from traffic
- Grinding can control and prevent RCF, but planning of preventive grinding should be based on several factors, including tonnage, track curvature, and friction control.

FUTURE WORK

Performance monitoring of these rail test curves at both mega sites continues. With more test data, a cost benefit analysis will be performed between TOR friction control and preventive grinding implemented to prevent/delay RCF.

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