

"INTERIM RESULTS OF NORFOLK SOUTHERN RAIL GRINDING TESTS"

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Summary

The Association of American Railroads and participating member railroads — Norfolk Southern (NS) (testing began in December 1993), the Canadian National (July 1995), and the Union Pacific (October 1996) — are conducting tests in revenue service to quantify the effect of rail grinding on fatigue and wear performance of head hardened rails. Only the NS test has accumulated enough tonnage to present results. After 215 MGT of traffic, the following observations were made:

- High-rail internal fatigue defects (shelling and detail fractures — often considered the main reason for grinding) have not been detected at this time in any of the test curves.
- Grinding appears to have no effect on spalling in this experiment; however, rail type seems to have a major influence.
- Grinding appears to increase wear rates on the gage face of the high rail and on the head of the low rail (unless the low rail was severely spalled).

Tests are conducted by applying three different rail profile maintenance practices in similar curves and evaluating the wear and fatigue performance of the rail. Rail profile maintenance practices under evaluation include: "no grinding," a "one pass" grind, and a more substantial "two pass" grind that is typical of most North American rail grinding practices.

Suggested Distribution:

- Maintenance of Way
- Maintenance Planning
- Track Maintenance
- R&T Dept.



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INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) and the Norfolk Southern (NS), Canadian National (CN), and Union Pacific (UP) railroads are conducting rail grinding tests as part of the Wheel/Rail Profile Optimization Project. The goal of these tests is to determine the effect of rail grinding on rail life in curves. Ultimately, the results will be used to develop optimized rail maintenance practices.

The first test began in 1993 on the NS, the second began on the CN in July 1995, and the third test began on the UP in October 1996. To date, approximately 215 MGT has been accumulated on the NS test, which has produced the following interim results concerning rail fatigue and wear:

- ▶ Rail internal fatigue defects have not been detected in any of the test curves.
- ▶ Substantial low-rail spalling (that the NS deemed necessary to grind out) occurred in three of 13 test curves with an identical rail type and similar curvature, but with two different grinding practices and one with no grinding.
- ▶ Three of four curves with one rail type have severely spalled, while none of the nine curves with another rail type have spalled to this extent.
- ▶ Three of the four non-ground curves have surface conditions as good as the ground curves.
- ▶ Grinding low rails that weren't severely spalled increased the vertical wear rates.
- ▶ Grinding high rails increased the gage wear rates.

TEST SITE

Thirteen test curves were selected on the NS near Roanoke, Virginia, on tracks that accumulate approximately 65 MGT of coal traffic each year. Test sites fall into three categories of track curvature: mild (2.4 to 2.9

degrees), intermediate (4.4 to 6.2 degrees), and sharp (7.0 to 8.4 degrees). CF&I head hardened rail is used in all curves and Rodange head hardened rail is used in several intermediate curves (Exhibit 1).

Exhibit 1. Track Curvature

C= CF&I R= Rodange

Grind	Mild	Intermediate	Sharp
None	1C	1R, 1C	1C
One pass	1C	1R, 1C	1C
Two pass	1C	2R, 1C	1C*

*Rail removed for non-test purposes.

Rails in the test area were usually well lubricated with the average gage face coefficient of friction of 0.28.

Three rail profile maintenance practices are used in each range of curvature in the NS test: (1) no grinding, (2) a light "one pass" grind, and (3) a "two pass" grind. The one pass grind produces gage corner relief of approximately .010 to .015 inch. The two pass grind is similar to a mild curve practice recommended by grinding contractors that produces gage corner relief of 0.025 to 0.035 inch. Rails have been ground every 35 MGT.

FATIGUE

Internal rail fatigue defects (shells and detail fractures) have not been detected in any of the test curves. Reduction of internal high rail fatigue is a primary objective of rail grinding. Until longer-term fatigue results are available from this project, potential benefits of grinding cannot be quantified.

Low-rail spalling, another primary objective of rail grinding, has occurred in four curves. Spalling first appeared in a two-pass curve with Rodange rail at 110 MGT and was ground out with extra passes of the grinder. The defects have returned but are not as severe as before. Low-rail spalling next



occurred in a one-pass curve with Rodange rail at 180 MGT. The spalls first occurred where water had collected next to the track, but have since appeared to a lesser extent throughout the entire curve. The rail grinder passed over these defects at accumulated tonnages of 180 and 215 MGT, not to remove the spalls, but with one pass each time to see if the spalls could be worn away. Spalls still remain in the rail.

Severe spalling has most recently occurred at 180 MGT in a no grind curve with Rodange rail. This spalling, which became severe by 215 MGT (shown in Exhibit 2), was associated with mild corrugations. The spalls were ground out with 5 passes of an 80 stone grinder. Of the four no-grind curves, one has been ground (only on the low rail) while the other three still have good surface conditions and have not been ground.



Exhibit 2. Spalling in a "No Grind" Curve. All Grinding Practices with Rodange Rail have Spalled .

Moderate spalling has occurred in another two pass curve with Rodange rail. By 215 MGT, all curves with Rodange rail (all in the intermediate curvature range) had spalled, severely in three curves, and moderately in the other.

LOW-RAIL WEAR

Low-rail wear rates were analyzed as a function of the number of passes made at each grinding interval, as illustrated in Exhibit 3. The best fit line clearly shows a trend of increasing wear rate with increased grinding. Wear increased with the number of passes for two reasons: (1) material removed during grinding, or grinding wear, adds to the natural wear of the rail and (2) natural wear is higher in the ground zones probably because the wear-resistant work hardened layers are removed by grinding. Also, crowning of the rail during grinding tends to increase the contact stresses. Contrary to expectations, there was no relationship apparent between low-rail wear and track curvature.

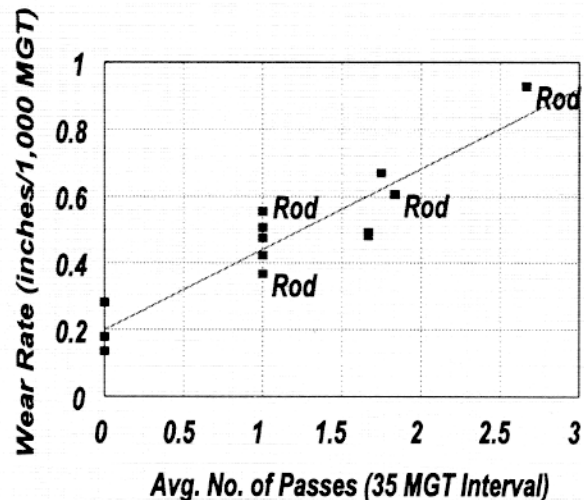


Exhibit 3. Low-Rail Wear Rates as a Function of the Average Number of Rail Grinder Passes Made Per 35 MGT Interval (CF&I Rail Unless Indicated "Rod" for Rodange)



Some of the grinding that has contributed to low-rail wear was deemed necessary for the removal of spalls. Exhibit 4 illustrates the relative height of the spalled no-grind Rodange rail as a function of tonnage. This rail was ground only once (at 215 MGT) to remove spalls. Because the slope of the line in Exhibit 4 represents the rail wear rate, it is clear that the wear rate increased as spalls developed. Removal of the spalls by grinding may ultimately reduce the wear rate to the "pre-spall" rate and extend the rail's wear life.

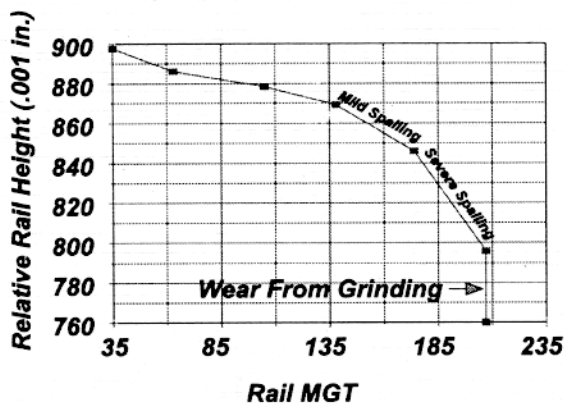


Exhibit 4. Relative Rail Height of No Grind Rodange Low Rail that Spalled and was Ground to Remove Spalls at 215 MGT

HIGH-RAIL GAGE WEAR

High-rail gage wear rates were analyzed as a function of average gage corner relief, as shown in Exhibit 5 (only CF&I rail was used to eliminate the influence of the different Rodange rail hardness on the regression plot). One of the test rails was removed for non-test reasons. The best fit line shows a trend of increasing wear rate with increasing gage corner relief. The scatter of data around the best fit line is probably caused primarily

by high-rail lubrication variability in the test curves. Again, there was no correlation apparent between wear rate and track curvature.

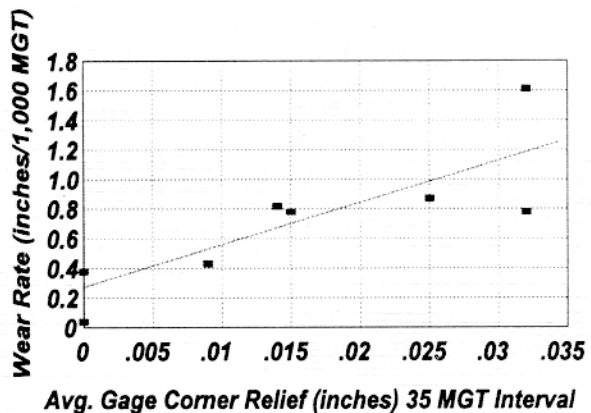


Exhibit 5. Gage Wear Rate of CF&I Head Hardened Rail as a Function of Gage Corner Relief by Grinding at 35 MGT Intervals

UPDATE OF OTHER TESTS

Tests on the CN railroad began near Kamloops, B.C., in July 1995 on a 50 MGT per year line. Rails in the 3- and 6-degree test curves are ground according to the following practices: (1) ground every 11 MGT, (2) ground every 22 MGT, or (3) are not ground at all. Preliminary wear results are similar to those from the NS test and suggest grinding contributes substantially to rail wear.

The UP railroad rail grinding test began in October 1996 near La Grande, Oregon, on a 55 MGT per year line. Rails in sharp curves (7- and 8-degree curves) will be ground once per year or less.

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