

### "INTERIM RESULTS OF NORFOLK SOUTHERN RAIL GRINDING TESTS"

by Jon Hannafious and  
Stephen Mace  
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#### Summary

As part of the Wheel/Rail Profile Optimization Project, the Association of American Railroads (AAR), and the Norfolk Southern (NS) and Canadian National (CN) railroads are conducting tests in revenue service to quantify the effects of rail grinding on the fatigue and wear performance of premium head hardened rails. Test results will be used to develop optimized rail maintenance practices.

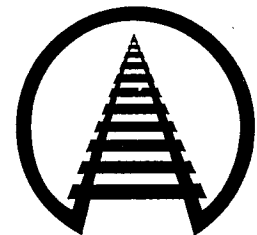
Test rails on the NS, installed in May 1993, have accumulated enough tonnage (143 MGT) to allow for accurate wear rate calculations. CN tests, which began in June 1995, have not accumulated enough tonnage for such calculations. Interim results from the NS test suggest the following:

- ▶ Rail internal fatigue defects have not been detected in any of the test curves.
- ▶ The rail surfaces in all but one test curve appear to be in good condition.
- ▶ High-rail gage corner grinding and inadequate lubrication increased gage wear rates.
- ▶ Low-rail wear rates appear to be directly related to the number of grinding passes.
- ▶ There appears to be no correlation between curvature and rail wear in the test curves.

The tests are conducted by applying three different rail profile maintenance practices to similar curves and evaluating the wear and fatigue performance of the rails. The three rail profile maintenance practices include: (1) no grinding, (2) a light "one-pass" grind, and (3) a more substantial "two-pass" grind. The NS test grinding interval is fixed at two grinds per year, for an average interval of 36 MGT.

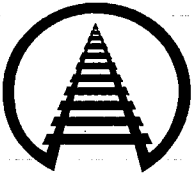
#### Suggested Distribution:

- Research and Development
- Maintenance Planning
- Track Maintenance
- Maintenance of Way



Association of American Railroads  
Research and Test Department

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## INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) and the Norfolk Southern (NS) and Canadian National (CN) 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 test results will be used to develop optimized rail maintenance practices.

While the first rail grinding test began in December 1993 on the NS, the second test did not begin on the CN until July 1995. To date, approximately 143 MGT has 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.
- ▶ The rail surfaces in all but one test curve appear to be in good condition.
- ▶ High rail gage corner grinding and inadequate lubrication increased the gage wear rates.
- ▶ Low-rail wear rates appear to be directly related to the number of grinding passes.
- ▶ There appears to be no correlation between curvature and rail wear in the test curves.

## TEST SITE

Thirteen test curves were selected on the NS near Roanoke, Virginia on tracks that accumulate approximately 72 MGT of traffic each year. The curves fall into three categories: (1) mild, (2) intermediate, and (3) sharp. Most test curves receive some lubrication, however, rail friction varies with the curve location and with time.

## GRINDING PRACTICES

Three rail profile maintenance practices are used in the NS test: (1) no grinding, (2) a light "one-pass" grind, and (3) a more substantial "two-pass" grind. The one-pass grind produces high-rail gage corner relief of 0.015 to 0.020 inch. The two-pass grind is a mild curve practice

recommended by the grinding contractor that is producing 0.030 to 0.040 inch of gage corner relief.

Table 1 contains information on the NS test curves, grinding practices, and wear rates; the curves were ground at the intervals shown in Table 2.

## RAIL FATIGUE

Internal rail fatigue defects (shells and detail fractures) have not yet been detected in any of the test curves. Reduction of internal fatigue is a primary objective of grinding. Until such "long term" results are available, a potential benefit of grinding will remain unquantified in this project.

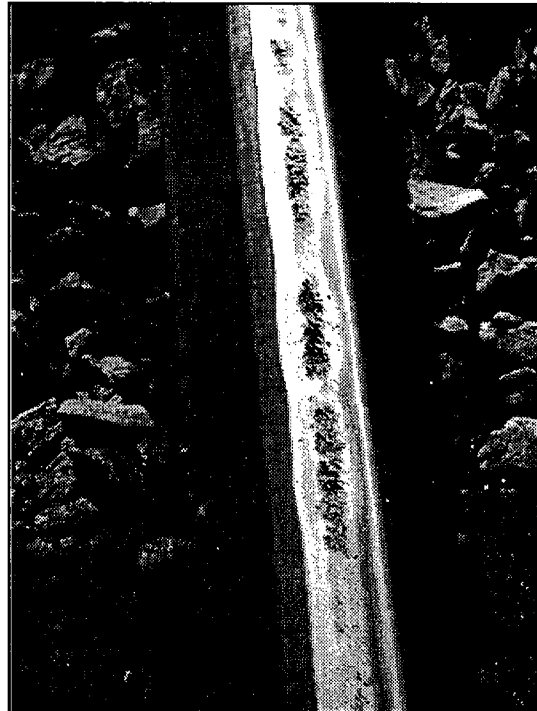


Figure 1. Spalling in Two-Pass Grind Curve

Another fatigue issue being addressed in this test is surface fatigue (spalling). To date, rail surfaces in most of the test curves appear to be in good condition. Heavy, low-rail spalling was observed, however, in one curve which receives two-pass grinding (Figure 1).

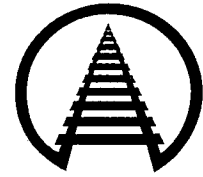


Table 1. NS Test Curves, Grinding Practices, and Wear Results

1. Curve Category	2. Deg. Of Curve	3. Rail Mfg.	4. Grinding Practice	5. Avg. High Rail Gage Relief (in.)	6. Avg. Grinder passes per interval (every 36 MGT)		7. Estimated HR Gage coefficient of friction	8. Wear Rates (in/1,000 MGT)	
					High Rail	Low Rail		Gage	Low Rail
Mild	2.8	CFI	No Grind	-	0	0	0.15	0.02	0.08
Mild	2.4	CFI	One-Pass	.015	1.0	1.0	0.40	0.69	0.43
Mild	2.9	CFI	Two-Pass	.031	1.75	2.0	0.30	0.65	0.55
Interm.	4.4-5.4	Rod.	No Grind	.005*	0.25	0.25	0.20	0.45	0.20
Interm.	5.0	Rod.	One-Pass	.017	1.0	1.0	0.25	0.81	0.24
Interm.	5.0-5.9	Rod.	Two-Pass	.036	1.75	2.5	0.35	1.14	0.65
Interm.	4.4	Rod.	Two-Pass	.035	1.75	1.75	0.25	0.78	0.51
Interm.	4.7-5.2	CFI	No Grind	-	0	0	0.30	0.21	0.13
Interm.	5.8-6.2	CFI	One-Pass	.013	1.0	1.0	0.15	0.22	0.37
Interm.	5.4	CFI	Two-Pass	.040	2.0	1.5	0.30	0.59	0.37
Sharp	7.8	CFI	No Grind	-	0	0	0.30	0.11	0.17
Sharp	7.0-8.4	CFI	One-Pass	.018	1.0	1.0	0.40	0.50	0.33
Sharp	7.8	CFI	Two-Pass	.032	2.0	1.75	0.30	0.85	0.52

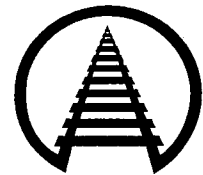
\*Rail was originally ground with one pass, then changed to a no-grind curve.

1. Curvature category - Mild, Intermediate, and Sharp
2. Degree of Curvature
3. Rail Manufacturer, CF&I or Rodange
4. Rail grinding practice based on target number of passes per interval
5. Average high rail gage corner relief ground onto the rail every 36 MGT
6. Average number of rail grinder passes made every 36 MGT
7. Estimated coefficient of friction of high rail gage face
8. Wear rates of high rail gage face (horizontal wear) and low rail head (vertical wear)

Table 2. Rail Grinding Schedule and Accumulated Tonnage of NS Test Rail

	Rail installed	Grind 1	Grind 2*	Grind 3	Grind 4
Date	May 1993	Dec. 1993	June 1994	Jan. 1995	July 1995
Tonnage	0 MGT	40 MGT	68 MGT	110 MGT	143 MGT

\*Undercutting of track forced six-week shutdown in spring of 1994.



By grinding the spalled rail to remove the defects, the low-rail wear rates have been increased substantially. Furthermore, the spalling may be related to increased gage corner relief of two-pass grinding. The AAR has demonstrated that unlike the more formal rail profiles, heavy gage corner grinding can increase the lateral wheel forces applied to the low-rail (Technical Digest 95-006). The AAR has also observed trucks that produce large lateral forces "scuffing" the surface of the low-rail. These scuffs may contribute to spalling.

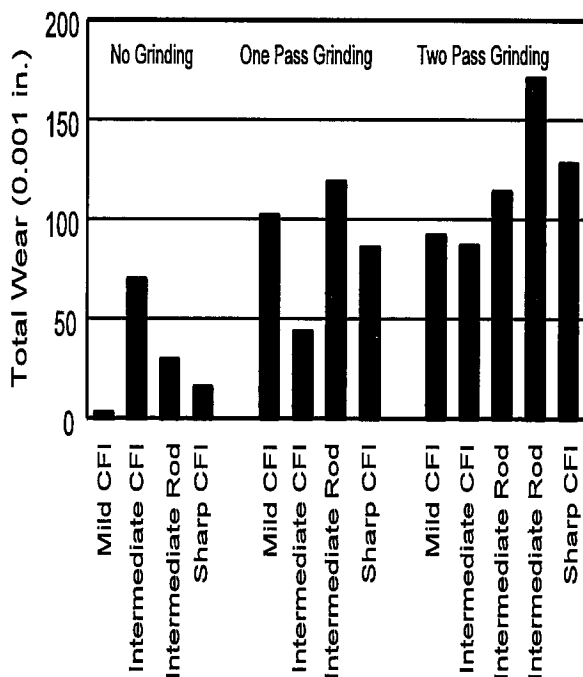


Figure 2. Total High-Rail Gage Wear in 143 MGT

### HIGH-RAIL GAGE WEAR

Figure 2 shows the total gage wear measured in the NS test curves. In most cases, the gage wear increased with increased gage corner grinding, even though the gage face of the rail was never ground. Thus, the increase in gage wear appears to have been caused by an increase in lateral flange forces in the curves. This supports the idea that heavy high-rail gage corner grinding can reduce truck steering and increase lateral forces.

### LOW-RAIL WEAR

Low-rail wear increased with the number of grinding passes, as shown in Figure 3, for several reasons. First, grinding removed material directly from the surface of the rail. Second, grinding removed the wear-resistant work-hardened surface layer. Finally, grinding restored the rail crown, which increased the contact stresses.

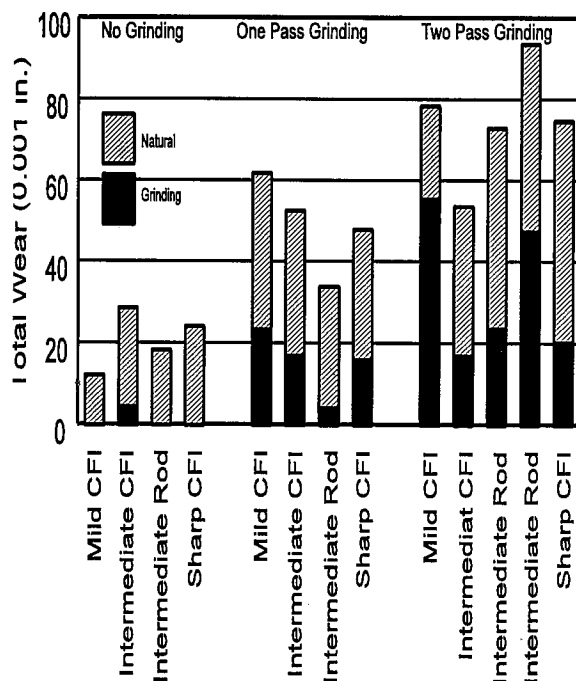


Figure 3. Total Low-Rail Wear in 143 MGT

### WEAR/GRINDING RELATIONSHIP

The relationship between wear and grinding in the NS test data was analyzed using a first order regression analysis. Surprisingly, no correlation was found between wear rate and curvature. The high-rail gage wear rate was analyzed as a function of average gage corner relief, as shown in Figure 4. The best fit line shows a clear trend of increasing wear rate with increasing gage corner relief. The scatter of data around the best fit line is caused primarily by the high-rail lubrication variability in the test curves.

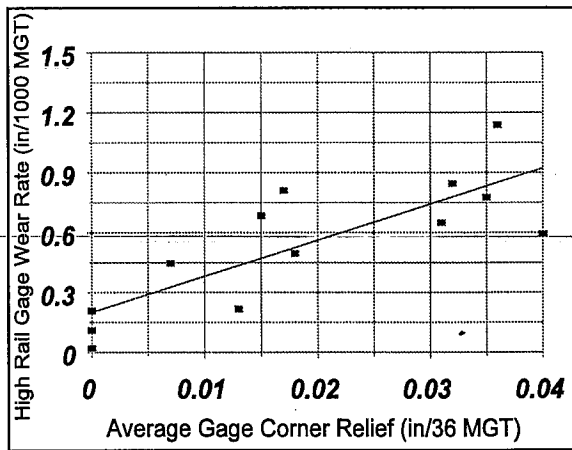
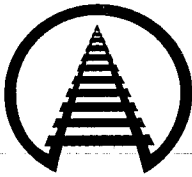


Figure 4. High-Rail Wear/Grinding Relationship

The low-rail wear rate was analyzed as a function of the number of grinding passes made at each grinding interval, as illustrated in Figure 5. The best fit line shows a clear trend of increasing wear rate with increasing grinding passes.

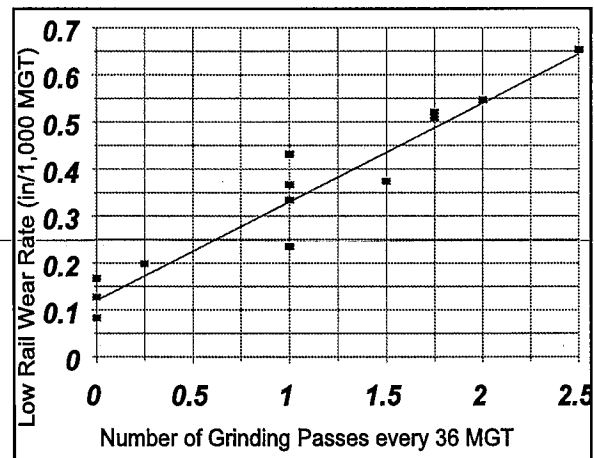


Figure 5. Low-Rail Wear/Grinding Relationship

Note: Contact Jon Hannafious on (719) 584-0682 or Stephen Mace on (719) 584-0563 with any questions or comments about this document.

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