TECHNOLOGY DIGEST

Timely Technology Transfer

Grinding Trial on Canadian National Railroad — Interim Results

by Kevin Sawley and Jon Hannafious

TD 97-040

Summary

Initial results of rail-grinding trials on the Clearwater Subdivision of Canadian National (CN) indicate that heavy grinding reduces the severity of damage to the rail surface. The tests — conducted exclusively on curved-track sites — yielded the following interim findings:

- Frequent (about every 12.5 million gross tons) and aggressive grinding controls cracks and spalls on the rail surface, and maintains the railhead profile desired by CN. This comes at the cost of higher rail-metal loss rates. More tonnage is needed to determine to what extent this type of grinding increases rail life by reducing defects due to rail fatigue.
- Unground control rails show more severe cracks and spalls on the rail surface, which threaten to impair ultrasonic inspection, but no rails have yet been removed from track.
- Internal railhead fatigue defects have not yet formed in any of the ground and unground rails at any site.
- There is no clear evidence that rail grinding has affected the natural wear of the rail caused by the passage of traffic.

Six test sites in total have been set up in curved track on the Clearwater Subdivision with the cooperation of CN. Rails in two sites are ground to normal CN practice, which involves frequent grinding to remove surface cracks and spalls, relieve the high-rail gage corner, and maintain the railhead profile desired by the railroad. Rails at two other sites are lightly ground at longer intervals. Control rails at the last two sites remain unground.

All rails at the sites are fully head-hardened, and were installed in May 1995. To date the sites have accumulated 100 million gross tons of traffic. Visual observations and measurements of rail profile are made periodically to establish performance. The work is part of a larger study by the Association of American Railroads to examine how rail grinding affects rail performance. The trial is continuing.

Suggested Distribution:

- ❑ Planning & Analysis
- ❑ Maintenance of Way
- ❑ Maintenance Planning
- ❑ Track Maintenance

Association of American Railroads
Railway Technology Department

October 1997

INTRODUCTION AND CONCLUSIONS

The Association of American Railroads (AAR) is working with Canadian National (CN) to study how the frequency of rail grinding, and the rate of metal removal, affects the development of rail defects. Six test sites have been set up in curved track on the Clearwater Division of CN. Two sites are being ground to normal CN practices. In addition, two are being lightly ground at longer intervals, and two are being left unground as control sites. Visual observations and rail-profile measurements are being made periodically to establish performance. Installed in May 1995, the sites have accumulated 99.7 million gross tons (MGT) of traffic. The trial is continuing, but interim results suggest:

- The CN practice of frequent and aggressive grinding controls surface cracks and spalls, and maintains the rail profile desired by CN. This comes at the cost of higher rates of metal loss.
- More tonnage is needed to see if frequent grinding reduces railhead fatigue defects, thereby leading to increased rail life.
- Internal railhead fatigue defects have not yet formed in any of the rails at any site.
- There is no clear evidence that rail grinding has affected the natural rate of rail wear rate, that is, wear caused by passage of traffic.

GRINDING TEST SITES

The six test sites are near Kamloops on the Clearwater Subdivision of Canadian National. The objective is to see how different grinding practices affect rail wear and the formation of rail defects (cracks and spalls on the rail surface, and shells/detail fractures inside the railhead). As cracks and spalls develop on the unground rails, there may be an opportunity to compare the merits of maintenance and corrective grinding. Exhibit 1 gives up-to-date details of the sites, which carry mainly unit trains and mixed freight at speeds of about 40 miles per hour.

Two grinding practices are being studied. The first is standard CN practice, where, on the Clearwater Subdivision, the rails are ground on average about every 12.5 MGT. The number of passes is based on rail condition, and it is standard practice to grind away all signs of cracks or spalls, and to relieve the gage corner on the high rail. The second practice is a single-pass light grind at about 6 miles per hour to skim the rail. This grinding is done at less frequent intervals than the CN practice. Two sites are left unground, unless CN staff decide grinding is needed to remove surface defects to keep the rail in track. The 136-4 CN section rails are head-hardened, made by Nippon Steel Corporation and NKK Corporation and installed in May 1995.

MEASUREMENTS AND OBSERVATIONS

The first site visit was made in September 1995, when the rails had tallied 11.8 MGT. It was reported that no grinding had been done. More visits were made at intervals up to May 1997, when 99.7 MGT of traffic had been carried. At each visit, transverse profiles of the high and low rails were made, usually before and after grinding, using the Miniprof rail-profile system.

Measurements made at 11.8 MGT are used as base data, against which all subsequent profiles are

Milepost	Curve	Elevation	Gage	Tie cant		Grade	Grinding practice
				High	Low		
44.8	6.5°	2 11/16 inches	56 5/8 inches	1.3%	1.4%	-0.3%	No grind
89.3	3.9°	3 7/16 inches	56 7/8 inches	0.9%	1.2%	0.1%	No grind
78.6	6°	3 7/8 inches	56 13/16 inches	1.4%	1.3%	0.1%	Single pass
78.8	3.2°	2 7/16 inches	56 7/8 inches	0.9%	1.3%	0.1%	Single pass
85.6	7.1°	4 inches	56 7/8 inches	1.1%	1.6%	-0.1%	CN practice
104.1	4°	2 5/8 inches	57 1/16 inches	0.9%	0.2%	0.1%	CN practice

Exhibit 1. Details of the Six Grinding Test Sites

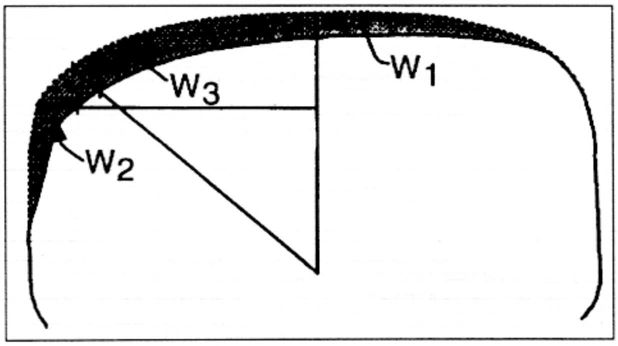

Exhibit 2. New and Worn Rail Profiles Illustrating the Wear Parameters. The Shaded Section is the Area A_P

compared. Exhibit 2 shows typical new and worn profiles and illustrates the parameters used to measure metal lost from the railhead by wear and grinding. W_1 gives the vertical loss, W_2 the horizontal loss, and W_3 the loss at the gage corner (all in millimeters). The area difference between the profiles gives the total amount of metal lost, Ap (square millimeters).

The visual condition of rail at each site was noted and the lubrication conditions recorded.

PROFILE MEASUREMENT RESULTS

At all six test sites, for both the high and low rails, the four metal-loss parameters (W_1, W_2, W_3 and Ap) increase approximately linearly with tonnage. This is shown in Exhibit 3, which gives the effect of tonnage on high-rail area loss at all six sites. The vertical steps in the graphs for Mile Posts 104.1 and 85.6 indicate the aggressive metal removal associated with the normal CN grinding practice.

Exceptions to this linear increase in metal loss are the gage corner (W_2) measurements on the low rails at all sites, and on the high rail at Mile Post 78.8. In all these cases there is no measurable loss of rail at the gage corner.

Exhibit 4 summarizes the total amount of rail metal lost from the high and low rails at all sites after 99.7 MGT of traffic. As expected, the greatest amount of metal loss occurred with the normal CN grinding practice. The next greatest loss was with single-pass grinding. The two sites with no grinding gave least metal loss.

VISUAL OBSERVATION RESULTS

Lubrication conditions throughout the study, and a summary of the visual observations made at 99.7 MGT, are listed in Exhibit 5.

As expected, cracking and spalling on the rail surface have been heaviest on the unground sites, and lightest on the sites ground to normal CN practice. CN staff report that the level of cracks and spalls on the unground rails leads to decreased reliability of ultrasonic inspection and would not normally be permitted. There has been no report of any rail removed for surface damage or internal railhead cracks such as shells and transverse defects.

DISCUSSION

Although interpretation of results from the six sites is made difficult by changes in lubrication conditions with time, and from site to site, some comments can be made.

CRACKS AND SPALLS

Frequent aggressive grinding controls surface cracks and spalls, and maintains the rail profile desired by CN. This comes at the cost of increased rates of metal loss. The high rates of rail grinding at sites 85.6 and 104.1 significantly reduced, but did not eliminate, surface cracks and spalls.

NATURAL RAIL WEAR RATES

Measurements at the Facility for Accelerated Service Testing have indicated that grinding increases natural wear rates on high and low rails. This has not been confirmed in this study.

INTERNAL RAIL DEFECTS

The benefit of aggressive grinding seen by CN is that it reduces internal railhead defects such as

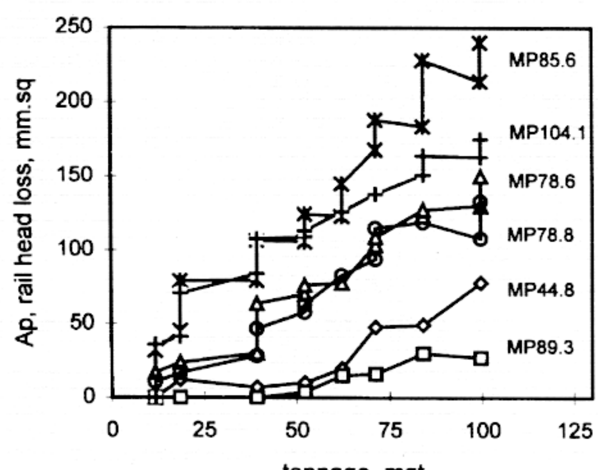

Exhibit 3. Effect of Tonnage and Grinding Practice on High-Rail Metal Loss

Milepost	High rail				Low rail			
	W_1, mm	W_2, mm	W_3, mm	A_p, mm^2	W_1, mm	W_2, mm	W_3, mm	A_p, mm^2
44.8 (No grind)	0.56	2.52	2.99	78	1.94	0	0	86
89.3 (No grind)	0.46	0.39	0.82	27	0.64	0	0	27
78.6 (Single pass)	2.23	1.22	2.96	150	2.96	0	1.72	181
78.8 (Single pass)	1.98	0	2.95	133	2.05	0	1.07	130
85.6 (CN practice)	3.11	3.03	4.42	240	3.7	0	1.75	236
104.1 (CN practice)	2.29	1.92	3.84	175	3.63	0	2.06	230

Exhibit 4. Summary of Railhead Metal Lost after 99.7 MGT

transverse defects. No such defects have yet been found at any of the sites. There are several possible reasons for this. First, more tonnage may be needed to initiate and grow defects. Second, head-hardened rail may have enough fatigue strength to resist defect formation. Third, internal defects tend to start at large inclusions. The NSC/NKK rails were rolled to CN clean steel specifications, and are likely to have few inclusions to initiate cracks. It may be that significant numbers of internal defects may not form during the life of the test rails.

To summarize, the trial has indicated that heavy grinding reduces the severity of rail surface damage. More tonnage is needed to determine to what extent rail life is improved by grinding.

ACKNOWLEDGMENTS

The authors would like to acknowledge the hard work and assistance provided by CN staff in this study. Especially they wish to thank W. Schwarz and D. Lynch.

Note: Contact Kevin Sawley at (719) 584-0636, or Jon Hannafious at (719) 584-0682 with questions or comments about this document.

E-mail: kevin_sawley@aar.com
jon_hannafious@aar.com

Site	Observations
44.8 No grind	Lubrication — poor on high and low rails for most of the study. Cracks and spalls — moderate to heavy on both rails.
89.3 No grind	Lubrication — fair to good on high rail, poor to moderate on low rail. Cracks and spalls — light to moderate on both rails.
78.6 Single pass	Lubrication — poor to good on high and low rails. Cracks and spalls — moderate to heavy on high rail, light to moderate on low rail.
78.8 Single pass	Lubrication — Poor to good on high and low rails. Cracks and spalls — light to moderate on both rails.
85.6 CN practice	Lubrication — fair to excellent on high rail, poor to excellent on low rail. Cracks and spalls — light on high rail, light to moderate on low rail.
104.1 CN practice	Lubrication — fair to excellent on high rail, poor to good on low rail. Cracks and spalls — light on high rail, light to moderate on low rail.

Exhibit 5. Summary of Visual Observations at the Six Sites

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON D.C., 20001