TECHNOLOGY DIGEST
Timely Technology Transfer

"Rail Profile Grinding Philosophies and Practices of Four U.S. Railroads,"

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Summary

Rail profile grinding philosophies and practices differ greatly among four railroads visited by the Association of American Railroads, Transportation Test Center (TTC), Pueblo, Colorado, for a rail profile project.

Four railroads were selected to test rail grinding in revenue service. Test sites were established and railroad and grinding contractors were interviewed on their grinding practices. All sites are located in heavy curve, steep grade territories with wayside lubricators.

Railroad 1 practices what is known as a "worn profile" grind, a term used to describe profiles that are very similar to naturally worn profiles, and grinds every 45 MGT. Railroads 2 and 3 are practicing a "two-point contact" profile. This indicates that the gage face on high rails of curves is separated from the top of rail by relief of the gage corner by grinding. Railroad 2 grinds just as the two-point contact disappears (25 MGT), while Railroad 3 allows the rail to wear-in completely before re-grinding (35 MGT). Railroad 4 grinds a two-point contact profile that is never allowed to wear to conformal; i.e., the interval between grinds is only 15 MGT.

On low rails of curves, Railroad 1 is using a near conformal profile of an 8-inch crown. Railroads 2 and 3 are using a 6- to 8-inch crown, and Railroad 4 a 4- to 6-inch crown. Though no defects have been documented at any of the test sites, isolated surface spalling of low rails has become an issue on all but Railroad 1.

Gage wear on high rails of curves and vertical wear on low rails are also important issues in grinding. Claims of reduced gage wear by grinding have been made by grinding and maintenance contractors. Information collected at TTC indicates that rail grinding only increases gage wear rates. Information collected in revenue service shows rail grinding can contribute significantly to vertical wear on low rails. Though rail grinding may extend rail life, benefits of grinding do not include reduced wear rates.

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INTRODUCTION

Substantial changes in the operating practices on major freight railroads have occurred over the last two decades. We have seen an increase in rail grinding budgets and an increase in the frequency of grinding, along with improvements in quality of rail, increased use of rail lubrication, and increased vehicle axle loads. At a time when some factors have worked to increase rail life (e.g. the head hardening of rail), other factors have seemingly reduced it (e.g. increased axle loads).

Rail grinding is universally thought to increase rail life, but grinding practices among railroads differ dramatically. At the request of member railroads that are aspiring to learn more about the issues of rail grinding, the Association of American Railroads (AAR), Transportation Test Center, Pueblo, Colorado, began the "Rail Profile Project" in 1991. Under this project, 24 test sites (21 curves and 3 tangents) were established on four railroads that have experience with rail grinding. The project includes: field observations of grinding (measurements of wear and profiles); interviews of railroad and rail grinding contracting personnel; and to better understand the effect of rail profile on vehicle curving forces, modeling with AAR's vehicle simulation program NUCARS. This phase of the project is scheduled to be completed in December 1994.

SURVEY OF RAILROADS

Railroad grinding practices at the test sites are described below. All sites are located in heavy curve, steep grade territories with wayside lubrication and most often premium rail (head hardened or fully heat treated). Exhibit 1 illustrates pre- and post-grind profiles from the high rails of sharp curves on the four surveyed railroads. Exhibit 2 summarizes their profiles and grinding intervals.

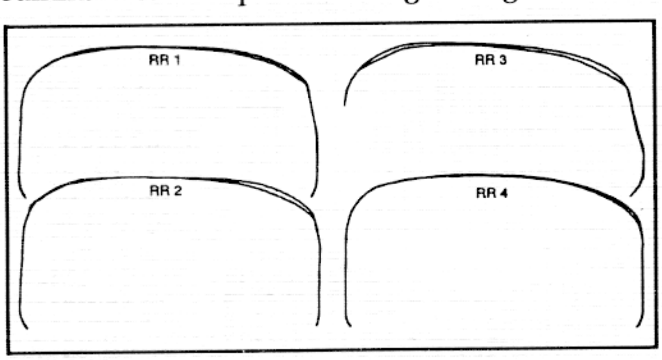

Exhibit 1. High Rail Pre- and Post-Grind Profiles of Surveyed Railroads

<u>**Railroad 1 (RR 1):**</u> Test sites are located on double track with concrete ties and Pandrol fasteners. Traffic is mixed freight and double stacks, with a few unit coal trains, making the average axle load lighter than at the other three railroad test sites. Grinding practice was designed and is controlled by an employee who selects rail grinder patterns that provide proper metal removal after inspection of the rail. Emphasis of rail grinding is on control of surface defects, promotion of a smooth running surface, and the influence on vehicle lateral curving forces.

This railroad grinds a "worn profile," a term used to describe post grind profiles that are very similar to naturally worn profiles. High rail gage corner relief is light (.010") and crowning of the low rail is mild (8" crown). Grinding interval is currently about 45 MGT.

Exhibit 2.
Summary of Railroad Grinding Practices

	RR 1	RR 2	RR 3	RR 4
Low Rail Crown Radius	8 in.	6-8 in.	6-8 in.	4-6 in.
High Rail Gage Relief	.010 in.	.025 in.	.025 in.	Never Wears in
Grinding Interval	45 MGT	25 MGT	35 MGT	15 MGT

<u>**Railroad 2 (RR 2):**</u> Test sites are located on concrete ties with Safelock fasteners. Traffic is mostly unit coal trains. Emphasis is on prevention of surface defects as well as gage corner defects that were a sizable problem with previous grinding practice. Previous grinding practice was described by this railroad as a worn profile. Grinding pattern is controlled with a bar gage supplied by the grinding company.

The practice used at the beginning of test was recommended by the grinding contractor and provided two-point contact on the high rails. This two-point contact disappeared just before the next grinding interval at 25 MGT. The low rail is ground to a 6- to 8-inch crown radius. The high rail grinding profile is now being modified to provide more gage corner relief. Grinding interval is about 25 MGT and is the second most frequent interval used among the railroads surveyed.

Railroad 3 (RR 3): Test sites are located on wood tie track originally equipped with cut spikes, but has been changed since to Pandrol plates and fasteners. Rail at this test site may flatten more than at the other sites because trains move as slowly as 10 mph up-grade. Cross level has been eliminated in the test curves due to low rail flattening. Grinding is emphasized to control metal flow and surface defects on both rails. As on RR 2, grinding profile is controlled with the bar gage.

The ground profile was originally similar to the RR 2's, providing two-point contact on the high rails of curves and a 6- to 8-inch crown on the low rails. However, both railroads now are modifying their high rail practices. RR 3's modification is opposite of RR 2's, toward a more conformal profile on the high rails of sharp curves. Grinding interval is currently about 35 MGT.

Railroad 4 (RR 4): Test sites are located on concrete ties with Pandrol fasteners and mostly head hardened rail. Traffic is unit trains (coal and grain) and mixed freight. High rail grinding practice was designed to address gage corner defects on high rails and surface defects on both rails. As on RR 1, profile is controlled by the experience of the grinding overseer and the expected metal removal of grinder patterns.

Grinding interval is more frequent here than on the other railroads surveyed at 15 MGT. The high rail gage corner is relieved, but the amount of relief from worn wheel contact could not be measured because the rail is not allowed to wear in; i.e., the wheels passing over the sites never contact the gage corners. The low rails are sharply crowned to a 4- to 6-inch radius.

REASONS FOR GRINDING

Though rail grinding practices vary from railroad to railroad, railroads grind for some or all of the following reasons:

1. Extend rail life by reducing the occurrence of rail fatigue: internal shells and detail fractures in gage corners of high rails of curves; surface spalling and head checking (rolling contact fatigue).

2. Extend rail life by reducing gage wear in curves.

3. Provide a smooth running surface by reducing/eliminating metal flow, corrugations and weld/joint batter.

4. Influence vehicle curving and hunting by partial control of the wheel/rail interaction.

Reducing the occurrence of internal and surface fatigue. There is probably not enough rail included in our survey to draw any conclusions about the effect of profile on internal fatigue, unless extensive internal fatigue defects develop at one given test railroad. There is enough however to determine effects of grinding on surface fatigue.

Fatigue defects have not been documented at any test sites to date. However, information gathered from interviews suggest that spalling has occurred in head hardened rail on isolated low rails on Railroads 2, 3, and 4. These railroads, experienced in grinding, have been unable to completely suppress spalling. The spalling on RR 4 comes as a surprise because its frequent grinding interval was designed to prevent spalling. The fact that spalling of premium rails on Railroad 1 has not been an issue may be attributed to the lighter average axle load. But it is conceivable that the more conformal profile used may lower contact stresses and thus inhibit spalling. The effect of crown radius on spalling is currently under evaluation at Facility for Accelerated Service Testing (FAST).

Rail Wear. Though rail wear life has been greatly extended with the use of lubrication, wear is still the cause of most rail replacement; i.e., gage wear on the high rails and height loss on the low rails of curves. Claims of reduced gage wear through rail grinding are often made by rail maintenance contractors. Data from grinding tests at FAST reveal that gage wear is indeed affected by the rail profile ground onto the rail. Gage face wear rates of three different grinding practices in a 5-degree curve at FAST are illustrated in Exhibit 3. The implication here is that grinding will only increase the gage wear rate, and the more the gage corner of a high rail is relieved, the higher the resulting wear rate will be. Since gage wear rates are all increased with grinding, many of the claims of decreased wear by grinding can be discounted.

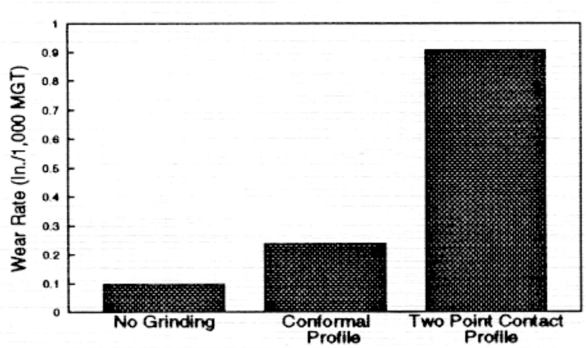

Exhibit 3. Gage Face Wear at FAST

Determining effects of rail profile on wear in revenue service requires varying the high rail profile from conformal to two point contact in like curves on one railroad. Since the railroads visited for the AAR Rail Profile Project used unvarying ground profiles, information gathered won't depict any effect of profile on gage wear. Additional test sites have been initiated on the Norfolk Southern Railroad and will include varying of profiles.

The Rail Profile Project has been successful in denoting that grinding contributes a significant amount of wear to low rails of curves. Measurements of rail height on RR 3 were collected before and after each grinding occurrence for two years and three-grinding occurrences. These measurements allow the wear to be broken down into natural wear and into metal removed by grinding. Exhibit 4 illustrates the total amount of rail wear on the low rail of curves (and one tangent test site) over 1.5 years or 66.5 MGT. The six test sites are in order by curvature along the x-axis.

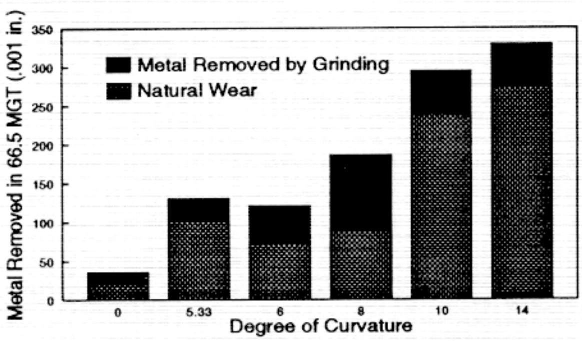

Exhibit 4. Railroad 3 Low Rail Wear

RR 3 data also shows increased wear with increased curvature. In Exhibit 5, linear regressions were calculated for the natural wear rate data and plotted as a function of curvature. This plot confirms the interviews about rail grinding; i.e., low rails of sharp curves are replaced more frequently than high rails by as much as a factor of three. For example, the low rail in a 14-degree curve on RR 3 will wear about 1 inch in only 250 MGT.

Providing a Smooth Running Surface. An obvious benefit of rail grinding is the ability to provide a smooth running surface by eliminating corrugations and joint/weld batter. A benefit enjoyed by railroads in the last 10 years has been the result of head hardened rails -- the ability of premium rail to resist corrugations. At FAST, severe corrugations have always developed in standard rail (less than 300 Bhn), often as deep as .1 inch by 80 MGT. But in head hardened rails, corrugations are usually not greater than .015 inch at well over 100 MGT.

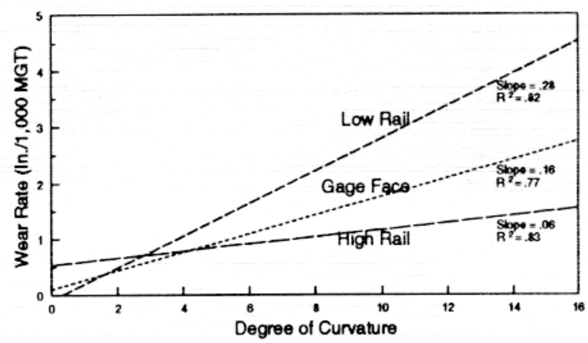

Exhibit 5. Railroad 3 Natural Wear Rates

Observations made at the four tests sites reinforce the limited need for grinding to address corrugations. Of the 21-curve sites visited (most sites were visited three times), only one developed visual corrugations. This was in the low rail of a 10-degree curve in concrete tie track on RR 2. These corrugations were documented after approximately 20 MGT of traffic and appeared to be about .010 inch deep. Another non-test location was visited on RR 3. This is a 14-degree curve through a tunnel with low rail corrugations observed at approximately 35 MGT. Both locations had stiff track and sharp curvature and required corrugation removal more frequently than less severe curves.

Influence on Vehicle Curving Forces. This topic requires too much clarification to describe thoroughly here. However, there are two ideals that apply to rail grinding and its influence on vehicle curving. The first is that steering is promoted with the use of "as worn" profiles on the high rails of curves; e.g., the high rail profile similar to that practiced by RR 1. Second, eliminating field side contact on the low rail will often decrease the likelihood of that rail to turn over as it does in low rail rollover derailments. All railroads visited practice this type of low rail relief by limiting contact to the center of low rails.

Note: Contact Jon S. Hannafious at (719) 584-682 with questions or comments about this document.

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, WILL BE AVAILABLE AT A LATER DATE THROUGH THE DOCUMENT DISTRIBUTION CENTER, CHICAGO TECHNICAL CENTER, 3140 SOUTH FEDERAL STREET, CHICAGO, ILLINOIS 60616. PHONE: BETTY J. VAUGHAN (312) 808-5421. A REPORT LIST IS AVAILABLE UPON REQUEST.