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Service Test Results of a New Designed Wheel Profile

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Summary

Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, has designed a new wheel profile named SRI-1A* under an Association of American Railroads' (AAR) Strategic Research Initiatives (SRI) Program. The intention of this new profile design is to improve vehicle curving performance and to reduce the wheel's wear-in period. Compared to the AAR-1B wheel profile, which produces a severe 2-point contact pattern with worn high rail, the SRI-1A wheel profile produces relatively conformal contact with typical worn high rail profiles in curves.

A service test of the new profile was conducted using a TTX five-unit articulated intermodal test car. Wheel performance was monitored to evaluate the lateral stability and curving performance using data received from the truck hunting detectors (THDs) and truck performance detectors that the test car passed.

The wheels were periodically inspected to obtain profile measurements and to document wheel surface conditions. The data from about 120,000 service miles showed that on curves the SRI-1A profile produced lower gage spreading forces (GSF) than the AAR-1B profile. The GSF reduction relative to the AAR-1B profile was reduced as mileage increased. The SRI-1A profile had lower wear at each evaluation stage. The AAR-1B wheels tend to have a higher rate of flange face wear and a higher level of asymmetric wear than the SRI-1A wheels. The hunting indexes received from 109 passes over THDs were below the detector alarm threshold of 0.2 for both profiles.

A second larger scale revenue service test is being conducted on a Norfolk Southern route using ten 100-ton capacity coal cars. The test results will be analyzed by TTCI to guide future implementation and to guide further wheel profile design modifications.

*The SRI-1A profile was previous named TTCI-1A profile.

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INTRODUCTION

As part of the AAR SRI Program to improve wheel life, TTCI developed a new wheel profile named SRI-1A. The intention of developing this new profile was to improve vehicle curving performance and reduce the wheel's wear-in period as compared to the AAR-1B wheel profile. Figure 1 shows the contact feature differences between the AAR-1B and SRI-1A profiles contacting with worn high rail in curves. *Technology Digest* (TD) TD-06-023 describes the profile development background and service test results up to 30,000 miles of operation using a TTX five-unit articulated intermodal test car.[1]

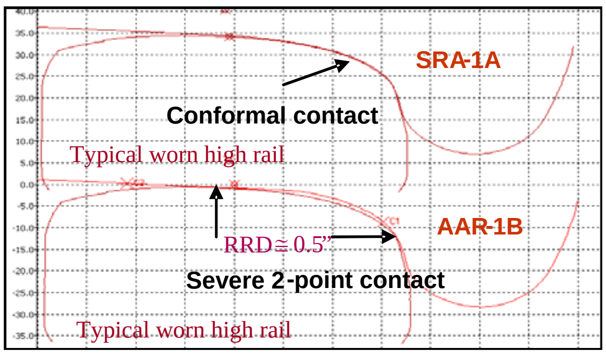

Figure 1. Contact Features of the SRI-1A and the AAR-1B Wheel Profiles

The wheel profile test using this car was concluded in October 2007, after 120,000 service miles of operation, because three axles were replaced (up to that time) due to wheel flats. Two of the three axles were originally equipped with the AAR-1B profile, and one axle was originally equipped with the SRI-1A profile.

This TD summarizes the results from the test.

SERVICE TEST RESULTS

The car chosen for this test contained six trucks. The wheels on three of the trucks were originally machined to the SRI-1A profile, while the remaining wheels were machined to the AAR-1B profile, as Figure 2 illustrates.

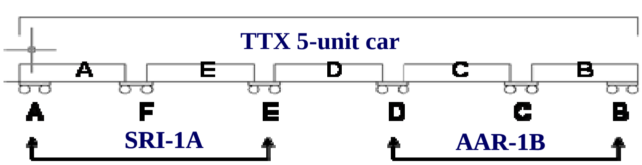

Figure 2. Five-unit Test Car Configuration

The test car's performance was monitored using THD and truck performance detector (TPD) data obtained from the InteRRIS® system. Over a 22-month test, the test car had 109 passes over THDs and 76 passes over TPDs. Note that not all passes over THDs or TPDs produced valid data due to detector problems at some sites. The test car traveled in service throughout the United States going back and forth from west to east. The test car was inspected five times during this test period to measure wheel profiles and to document wheel surface conditions to compare wear rate and RCF occurrences between the two types of wheel profiles.

Curving Performance

GSF is an indication for truck curving performance. It is defined as the summation of lateral forces on four wheels in a truck divided by two. Figures 3 and 4 show the average GSF results from two test periods. The SRI-1A profile produced lower average GSF than the AAR-1B profile in both periods due to relatively conformal contact with the typical worn shapes of high rails on curves. However, comparing Figures 3 and 4, the differences of the GSF between two types of wheel profiles reduced as mileage increased.

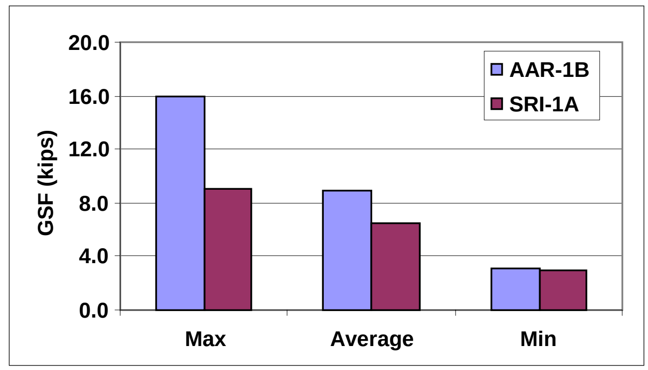

Figure 3. GSF in the First 0 to 30,000 Miles

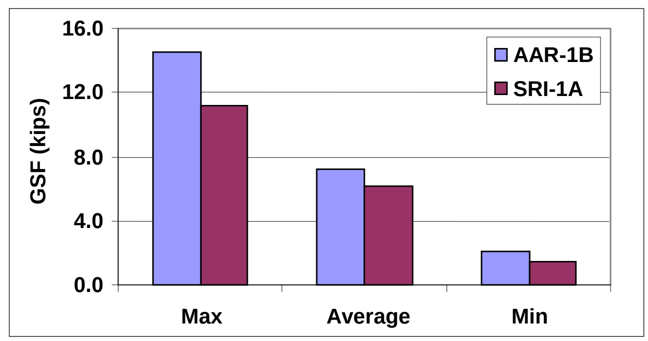

Figure 4. GSF from 30,000 to 110,000 Miles

Figures 5a and 5b show the average GSF differences between the two types of wheel profiles obtained as the test car traversed the TPD sites. The positive values indicate that the average GSF of the AAR-1B wheels is higher than that of the SRI-1A wheels. The negative values indicate that the average GSF of the AAR-1B wheels is less than that of the SRI-1A wheels.

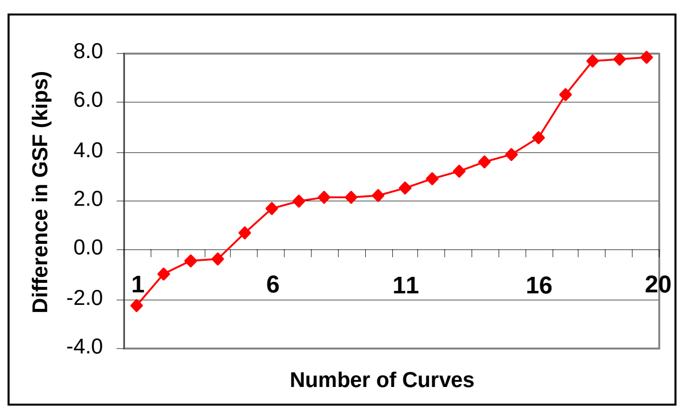

Figure 5a. Difference in GSF Occurrences 0 to 30,000 Miles

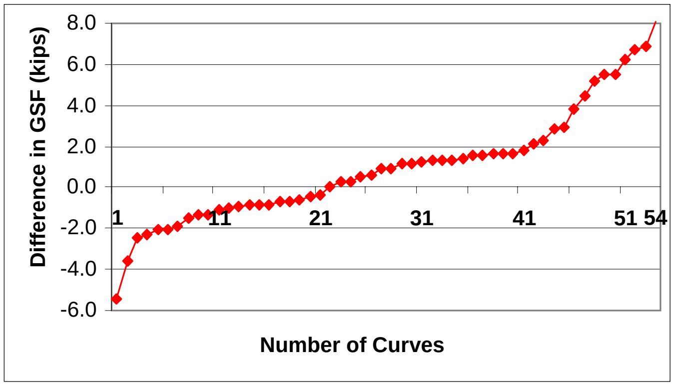

Figure 5b. Difference in GSF Occurrences 30,000 to 110,000 Miles

In the first 0 to 30,000 miles, from 20 curves with valid TPD data, the AAR-1B wheels produced higher GSF than the SRI-1A wheels due to the initial severe 2-point contact feature of the AAR-1B profile. A comparison of the positive and negative values in Figure 5a leads to a ratio of 15.4. Between 30,000 to 110,000 miles from 54 curves with valid TPD data as shown in Figure 5b, the AAR-1B wheels also produced higher GSF. However, the ratio reduced to 2.6. This reduction is expected. The AAR-1B wheels gradually lost the severe 2-point contact feature due to wear. Also, the asymmetric wheel wear of some AAR-1B axles curved better in certain direction of curves. This scenario will be discussed further in the section on wear and wear pattern.

Lateral Stability

The lateral stability of the test car was also monitored using data from THDs. Figure 6 summarizes the hunting index values from 109 passes over the THDs, which include loading conditions from empty to fully loaded. Neither the SRI-1A or the AAR-1B profile reached the industry threshold of 0.2 for hunting. Since no rail profiles were measured at the THD sites, the actual contact conicity of the wheels contacting with the rails at the THD sites could not be determined. To fully understand the performances of both wheel profiles over the THD sites, the correlation of contact conicity and hunting indexes will be further investigated in future tests.

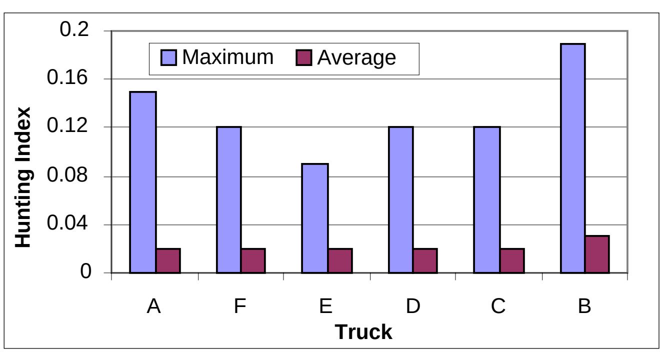

Figure 6. Five-unit Test Car Hunting Index

Wheel Wear and Wear Pattern

Wheel wear rate and wear pattern affect wheel life. Figure 7 shows the average cross-sectional area loss due to wear at three stages during the test period. The average wear of the SRI-1A wheels is about 20 to 10 percent less than the AAR-1B wheels at the three evaluation stages.

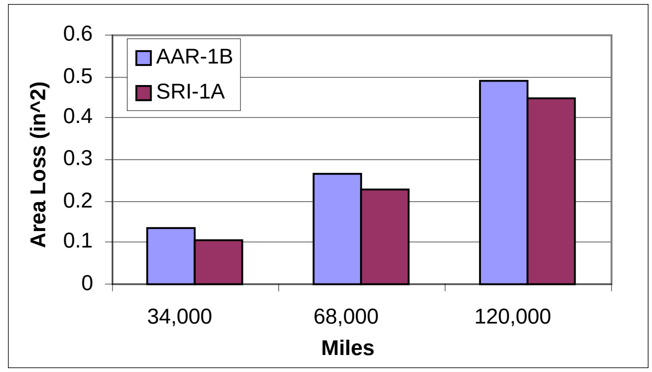

Figure 7. Average Wheel Total Area Loss

Figure 8 shows the average wear at the wheel flange face (measured at 0.6 inch from the flange tip), wheel tread (measured at the tapping line), and tread hollow after 120,000 miles of operation. The wheel tread hollow is measured by drawing a horizontal line on top of the tread end and measuring the maximum difference between this line and the wheel tread. As Figure 8 shows, the SRI-1A wheels have only little wear in the flange face compared to the AAR-1B wheels. The SRI-1A and the AAR-1B wheels have a similar level of average wheel tread wear. The SRI-1A wheels show slightly higher values of average wheel tread hollow (with both less than 0.07 inch). These wear patterns indicate that the SRI-1A wheels generally wear at wheel throat and tread, while the AAR-1B wheels mainly wear at the wheel flange face and tread. These trends are seen from the wheel profiles measured at the three evaluation stages.

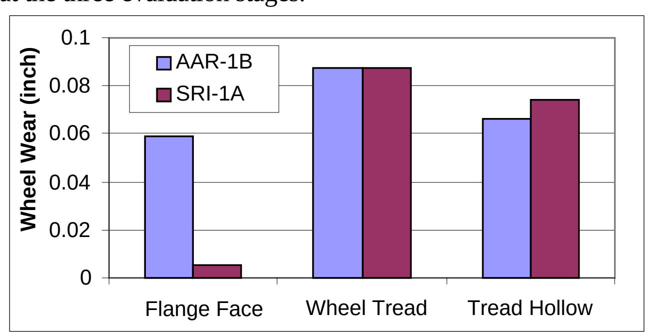

Figure 8. Average Wear in Wheel Flange Face, Wheel Tread, and Wheel Tread Hollow

Figures 9 and 10 show the profile overlays of left and right wheels of two axles on a truck to assess the asymmetric wear after 120,000 miles of operation.

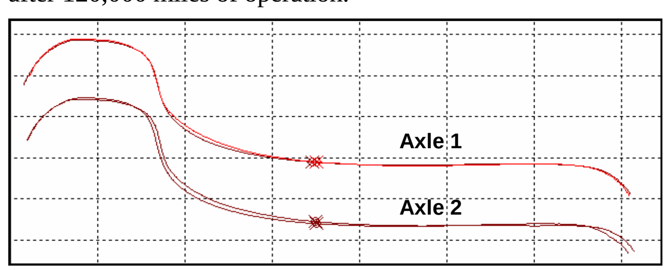

Figure 9. The SRI-1A Wheel Profile Overlay, Two Axles at 120,000 Miles

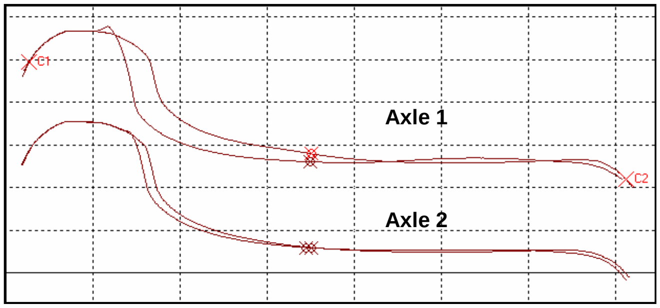

Figure 10. The AAR-1B Wheel Profile Overlay
Two Axles at 120,000 miles

Figure 11 further quantifies asymmetric wear at the three evaluation stages. The y-axis is the average difference in the cross-sectional area wear between left and right wheels. In the three evaluation stages, the SRI-1A wheels show minimal asymmetric wear, with the typical pattern shown in Figure 9. The AAR-1B wheels show considerable asymmetric wear, with the typical pattern shown in Figure 10, and this asymmetric wear tendency increases with operating mileage.

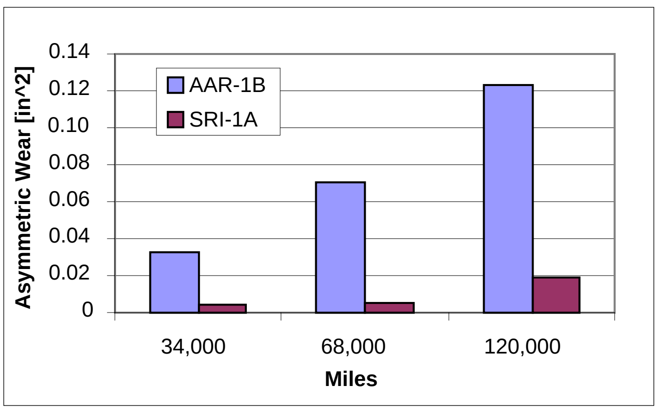

Figure 11. Quantification of Asymmetric Wear
at the Three Evaluation Stages

Asymmetric wheel wear can make a truck's curving performance dependent on the direction of travel through a curve. A truck may curve poorly in one direction of travel through a curve because the wheels on the low rail may have larger rolling radii than the wheels on the high rail. Conversely, this truck may perform well when operating in the reverse direction through the curve because of opposite arrangement of rolling radii. This effect has been observed in the TPD data.

Figure 12 shows the lateral forces of the test car as it traveled through a TPD site at about 88,000 miles. The two curves at this TPD site have same curvature of 3 degrees, but in reverse directions. As Figure 12 shows, the AAR-1B wheels produce higher lateral forces in the first curve, but much lower lateral forces in the second curve. The SRI-1A wheels produce similar levels of lateral force in both curves. A separate TD (TD-08-008) addresses the effects and formation of asymmetric wheels in more detail.[2]

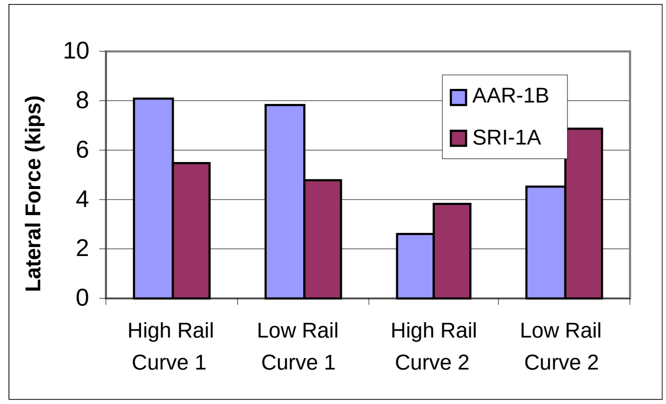

Figure 12. Test Car Leading Wheel Lateral
Forces through a TPD

The surface conditions of wheels on this test car had no clear indication of being related to the wheel profiles. Surface damages were more likely related to the brakes.

CONCLUSIONS

In the TTX five-unit articulated intermodal test car service test, the SRI-1A profile produced lower GSF than the AAR-1B profile. The GSF reduction relative to the AAR-1B profile was reduced as mileage increased. The SRI-1A profile had lower cross-sectional area loss at each wear evaluation stage up to 120,000 miles of operation. The AAR-1B wheels tended to have a higher rate of flange face wear and higher level of asymmetric wear than the SRI-1A wheels.

FUTURE WORK

A second larger scale revenue service test is being conducted on a Norfolk Southern route using ten 100-ton coal cars. The test results will be analyzed to guide future implementation or to guide further wheel profile design modification.

ACKNOWLEDGMENTS

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REFERENCES

1. Wu, H., B. Madrill, and S. Kalay. September 2006. "New Wheel Profile Design and Preliminary Service Test Results." *Technology Digest* TD-06-023, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.
2. Wu, H. and B. Madrill. February 2008. "Effect and Formation of Asymmetric Worn Wheels." *Technology Digest* TD-08-008, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.