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Contact **David Davis, (719) 584-0754** with questions or concerns regarding this *Technology Digest*. E-mail: david_davis@ttci.aar.com.

Long-Term Wheel Wear Evaluation of Heavy Axle Load Premium Trucks in Revenue Service

by **David D. Davis, Richard P. Reiff, and Beatrice Rael**

Summary

Transportation Technology Center, Inc. and Union Pacific Railroad have conducted a comparison of wheel profiles measured for over 4 years. One truck is a conventional three-piece design with improved lateral stability (referred to as the base case). The other has a premium suspension, improved steering design. Mileage on the cars ranged from about 260,000 miles to 420,000 miles. Two measurements were made on each wheel in the study: first at about 150,000–200,000 miles and again at about 300,000–400,000 miles. Total wear and long-term wear rate were calculated from the profiles. Since the study began after the cars were placed in service, a nominal AAR-1B profile was used as the initial (zero mileage) profile.

Conclusions re-affirmed by the latest measurement cycle include:

- Mileage affects wheel wear rate; older wheels show lower long-term wear rates. This is attributed to the work hardening of the wheels and the profiles becoming more conformal to the average rail profile. In addition, the highest wear rate wheels are reaching their service life and are being removed from the study population.
- Improved steering design trucks are continuing to perform well by exhibiting good wheel performance. Both flange wear and tread wear rates are lower than in the base case truck. The base case trucks have an 88 percent higher flange wear rate and a 31 percent higher tread wear rate. However, the difference in flange wear between the two groups has decreased from the earlier measurements.
- Variation in performance for each truck type is similar. There appears to be good and poor performance outliers in each group. The poor outliers are reaching wear limits and are being removed from the fleet. This is one reason that the differences in performance of the two groups are decreasing.
- Relatively small differences in wear rates were seen between the diagonal pairs of wheels in a truck for each truck type. This suggests that truck warping is not a major problem for this fleet.
- No significant differences were seen in wheel wear between the two truck types related to wheel location within the car. Axle number and vehicle side (L or R) are not critical to wheel performance. This suggests that the cars are turned frequently and the routes they travel on have a reasonable balance of left and right curves.

The cars in the study are 315-kip coal gondolas that are currently being loaded to 286 kips. The cars are operated on several long haul routes over 1,000 miles, and all loads originate in heavy curvature and grade territory.



Suggested Distribution:

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

INTRODUCTION AND CONCLUSIONS

A revenue service test of two premium performance trucks in 315-kip gross vehicle weight (GVW) limit cars was conducted by TTCI in conjunction with the Union Pacific (UP) Railroad. The two truck types were 1) a conventional three-piece design with improved lateral stability (base case); and 2) a premium suspension, improved steering design. Measuring wheel wear of the two car fleets over a substantial portion of their lives has allowed TTCI to assess truck performance. This *Technology Digest* describes the latest results from measurements made after 300,000 miles of service. A previous issue of *Technology Digest* describes the results of the earlier measurements made.¹

This revenue service test is a supplement to the improved suspension truck-performance evaluation done at the Facility for Accelerated Service Testing (FAST) under the Heavy Axle Load Experiment. This project, jointly sponsored by AAR and the Federal Railroad Administration (FRA), evaluated the performance of three improved suspension truck types and their effects on track degradation. The test at FAST was successful in demonstrating the reductions in lateral forces and component degradation that are possible. For example, average lateral loading in curves was reduced by 43 percent. However, the tests were limited to about 100,000 miles of operation (about 30 percent of a typical freight car's wheel life). The revenue service study reported here looks at the long-term performance of the trucks under revenue service conditions.

A comparison of profiles measured at UP in 1999 to the nominal new profile was made on 48 wheels in 315-kip cars equipped with improved steering trucks. The test team also measured 111 wheels from the base case trucks. Total wear and long-term wear rates were calculated from the profiles. The 1999 measurements were made after 150,000 to 300,000 miles of operation on the wheels. An additional measurement on as many of the surviving wheels as possible was made in 2001-2002. One hundred wheels were measured (48 from improved suspension trucks and 52 from base case trucks). Mileage ranged from 297,000 to 334,000 for the base case trucks and 257,000 to 420,000 for the improved steering trucks.

The cars in the study are coal gondolas that are currently being loaded to 286 kips. The cars have served a variety of coal shippers in Colorado and Utah; with destinations in the Midwest and West Coast. The route history of each car may be unique, but the general characteristics of each route are similar. All are long-haul routes of +1,000 miles, and all loads originate in heavy curvature and grade territory.

Conclusions drawn from the study include:

- Older wheels show lower long-term wear rates. This is attributed to the work hardening of the wheels and the profiles becoming more conformal to the average rail profile. In addition, the highest wear rate wheels

are reaching their service life and are being removed from the study population.

- Improved steering design trucks are continuing to perform well in steering, as indicated by wheel wear. Both flange wear and tread wear rates are lower than in the base case truck. The improved steering trucks have a flange wear rate that is 58 percent of the base case trucks. The improved steering truck's tread wear rate is 69 percent of the base case truck. However, the difference in flange wear between the two groups has decreased from the earlier measurements.
- Variation in performance for each truck type is similar. There appear to be good and poor performance outliers in each group. The poor outliers are reaching wear limits and are being removed from the fleet. This is one reason that the differences in performance of the two groups are decreasing.
- Relatively small differences in wear rates between the diagonal pairs of wheels in a truck for each truck type. This suggests that truck warping is not a major problem for this fleet.
- No significant difference in wheel wear related to wheel location within the car for both truck types. Axle number and vehicle side (L or R) are not critical to wheel performance. This suggests that the cars are turned frequently and the routes they travel on have a balance of left and right curves.

METHODOLOGY

Wheel wear rates are a function of many track, vehicle, and operating parameters, such as wheel load, train speed, rail profiles, and vehicle/truck suspension characteristics. The assumption made in this study is that the operating and track characteristics are the same for both truck types. The cars have been used in a variety of mine-to-terminal routes, but all are relatively long hauls with sections of grades, curves, and tangent running. This leaves truck type as the main independent variable in the wheel wear study. To determine the performance of the trucks, wheel profiles were measured from all eight wheels of a sample of cars. Union Pacific provided the mileage history for each car. Wear for each wheel was determined by comparing the measured profile to the nominal new AAR-1B narrow flange profile. TTCI has developed software that aligns profiles for comparison and calculates tread and flange wear as area loss. Long-term wear rates were calculated using the mileage records.

Figure 1 illustrates the comparisons made between wheels. These following comparisons were done to better determine the performance of the trucks and to verify the study assumptions:

- *Average tread and flange wear rates:* This involved using all wheels from each location on each car measured.

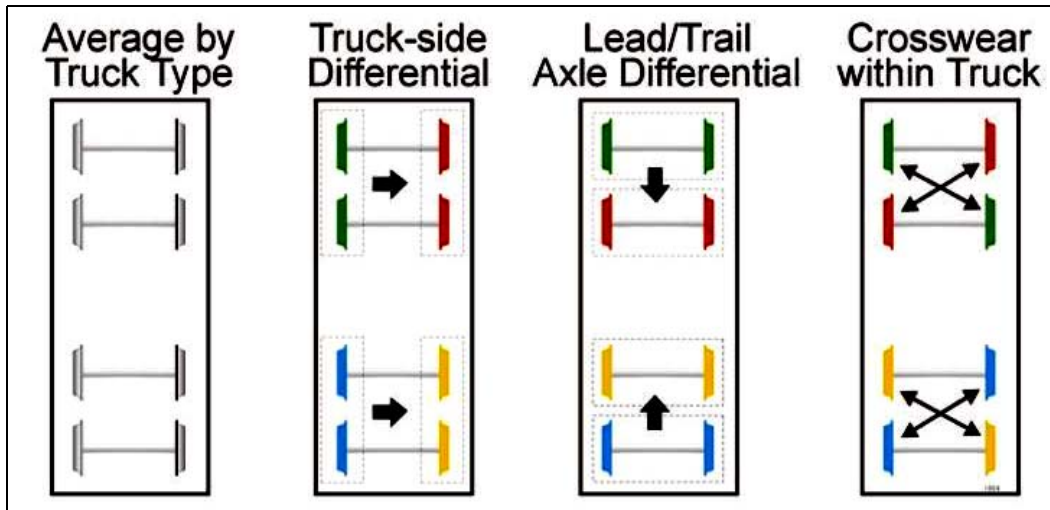


Figure 1. Wheel Wear Comparisons to Determine Truck Performance

- *Truck side differential wear rates:* Comparing the average of the four “A” (left) wheels to the four “B” (right) wheels. Large truck side differential wear would indicate poor steering trucks or route-specific problems.
- *Lead/trail axle differential:* Comparing the average wear of the wheels on the lead axle to the average wear of the wheels on the trail axle. Large values would indicate poor steering trucks or car directionality issues.
- *Cross wear within truck:* Comparing the average wear on wheels 1A and 2B with the average wear on wheels 1B and 2A. Large values indicate warping trucks.

RESULTS

Tread wear data in Figure 2 shows the effect of mileage on both tread and flange wear rates. The long-term wear rates are affected by the initial “break-in” wear rate and subsequent removal of some wheels for wear and defects. Wear rate has continued to decrease over the entire test measurement period.

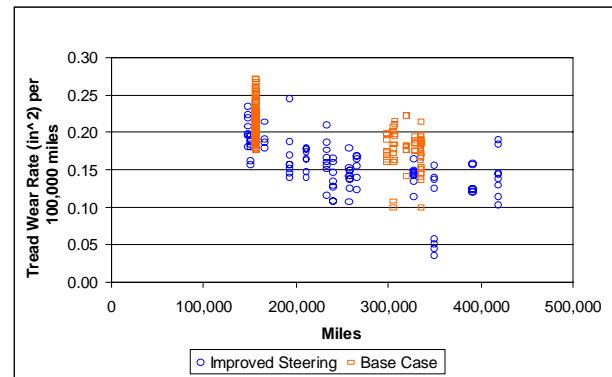


Figure 2. Tread Wear Rate versus Mileage

There is also a significant difference in average wheel wear rate between the truck types. Table 1 and Figure 3 show the differences between the two groups. The base case trucks have significantly higher flange wear rates (about 88%) and tread wear rates (about 31 percent). These figures have changed from the previous measurement as wear rates for both truck types decrease.

Table 1. Comparison of Wheel Wear Rates on the UP

Measurement Interval (mi.)	Improved Steering		Base Case		Base Case/ Improved
	250,000–420,000	0–420,000	297,000–335,000	0–335,000	
Number of wheels	48	48	52	52	NA
Tread wear (sq. in /100k mi)					
Average	0.10	0.13	0.14	0.18	1.31
Std dev	0.04	0.03	0.04	0.03	NA
Flange wear (in ² /100k mi)					
Average	0.04	0.06	0.08	0.11	1.88
Std dev	0.03	0.02	0.06	0.04	NA

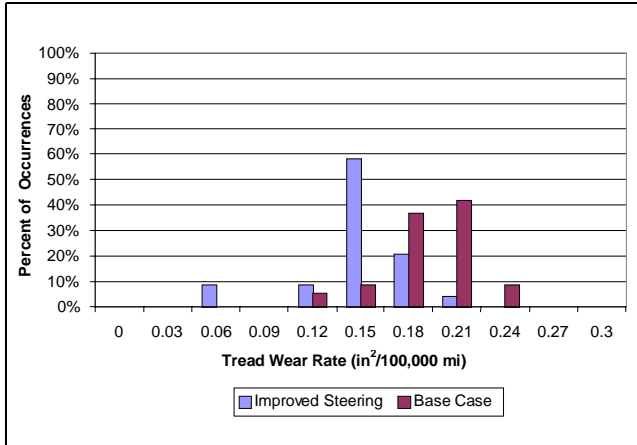


Figure 3. Tread Wear Rates of Improved Steering and Base Case Trucks

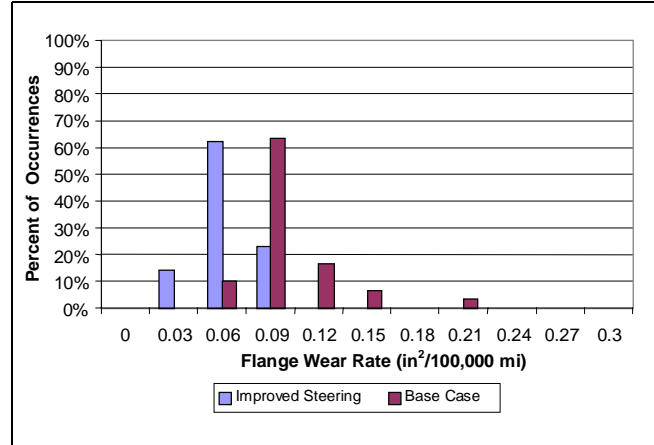


Figure 4. Flange Wear Rates of Improved Steering and Base Case Trucks

The interim results showed wear rates were about 100 and 20 percent higher for flange and tread wear, respectively. The results are statistically significant at the 95 percent confidence level. The latest results agree with long-term studies done by Canadian Pacific (CP) under 286 kip cars.² The CP studies showed that similar improved steering trucks reduced flange wear by 70 percent compared to its base case truck.

As Figures 3 and 4 show, the two populations are similar in variation but different in average wear rates. For both flange and tread wear rates, the two trucks show statistically significant differences in performance. This data comes from the second inspection.

FIELD OBSERVATIONS

Both groups of trucks have a wide range of wheel wear rates. This is illustrated in the relatively large standard deviations in wear rates relative to the means. One possible explanation of this range of performance is the lack of alignment of some axles. Both groups of trucks have outliers that should be investigated. Wayside inspection

devices such as truck performance detectors can be used to identify cars that generate high lateral forces. These cars will also have high wheel wear rates. Inspection of the cars and further factor analysis is needed to determine the causes of the outlier wear rates.

Flange tip deformation was noted on several wheel profiles. This deformation was located mostly toward the tread side of the flange tip. We speculate that these wheels were flange bearing at the yard trackage at either the loading or unloading points.

REFERENCES

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2. Roney, Michael D. and David K. Meyler, "A Case Study of Wheel/ Rail Cost Reduction on Canadian Pacific Railway's Coal Route," *7th International Heavy Haul Conference*, Brisbane, Australia, June 2001.

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