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Wheel Life Comparison 3-Piece versus M-976 Trucks

Analysis Case A: Two Train Sets of 135 Cars in Western Coal Service

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Summary

A comparison by the Transportation Technology Center, Inc. (TTCI) between revenue service wheel-life data from two car types in two different train sets, one fitted with 3-piece trucks and the other fitted with M-976 trucks, indicates a net improvement of wheelset miles to removal of 18 percent after 380,000 car service miles.

This improvement is attributed to a 3.5 times improvement in removals for wheel tread damage attributed, in turn, to the improved steering performance of the M-976 truck. This gain is offset, however, by a 6.6-fold increase in thin flange removals. This finding emphasizes the need to find a solution to asymmetric wheel wear associated with premature thin flange removals so as to derive full benefit from the reduction in high impact wheel removals associated with the M-976 truck.

Through the Association of American Railroads' Strategic Research Initiatives Program, TTCI was tasked to develop truck designs to improve current performance. Improved truck designs are to include both modifications to current trucks as well as the development of new design concepts.

A major problem identified through this research is that of high impact wheels (HIWs). HIWs are a major cost factor in car operation as well as a contributor to increased track maintenance and renewal costs. Car repair billing data shows that more than 582,000 wheels were removed in 2010 for HIWs in the North American railroad industry, resulting in an estimated cost of \$828 million.

HIWs, identified mainly through why made code 65 wheel removals, currently account for the largest percentage of wheel removals. Research indicates that these removals can be reduced by introducing improved steering trucks.¹ The M-976 truck design improves steering and was introduced into revenue service in 2004.



INTRODUCTION

TTCI was tasked to develop truck designs to improve current performance under the Association of American Railroads (AAR) Strategic Research Initiatives Program. Wheel life has been identified as a critical performance parameter. According to the AAR’s car repair billing database, the annual cost of wheel replacement in North America in 2009 was \$800 million per year.

HIWs are the cause for approximately 50 percent of wheel removals and their reduction is the primary focus for a future truck design. Research suggests that HIWs can be reduced through improved steering trucks.¹ The M-976 truck develops reduced steering forces that should reduce the incidence of HIWs.² Car owners have, however, reported an increased incidence of why made (WM) code 60 (thin flange) wheel removals on M-976 trucks.³ This could compromise gains due to the reduction of HIWs.

Analysis of the service life of wheelsets fitted to M-976 and pre-M-976, 3-piece trucks will:

- Quantify the role of improved truck steering on the incidence of HIWs and support the development of performance limits.
- Identify the number of WM 60 wheel removals and suggest causes for these wheel removals.

This *Technology Digest* (TD) reports on a comparison of wheelset removals from two train sets of 286,000-pound capacity coal cars operating on a western railroad: one group is equipped with standard 3-piece trucks and the other is equipped with M-976 trucks. Both train sets comprise 135 cars operating on similar routes during their service life. Table 1 provides further details of these cars.

Table 1. Details of the Two Car Groups Analyzed

Car Group:	1 (Pre-M-976)	2 (Post-M-976)
Number of Cars:	135	135
Build Date:	2000	2005
Truck Type:	3-piece, constant damped	Wide wedge, polymer adapter pads
Miles in Service	750,000 miles	380,000 miles

PERFORMANCE DATA

TTCI was supplied information on all wheel removals, together with the miles to removal, from the build date to the end of June 2008. The following data was removed:

- Mate wheel (WM 11 and 90)
- Repeat removals of the same wheelset in the car

This was done to provide a history of all originally installed wheelsets in the cars. The data was then classified into the following groups:

- Thin flange (WM 60)
- Tread (fatigue) damage resulting in HIWs (WM 65, 68, 71, 75)
- Tread slid flat (WM 78)
- Other (All other WM codes)

Miles to Wheelset Removal

Figure 1 shows wheelset removals sorted in ascending miles to removal.

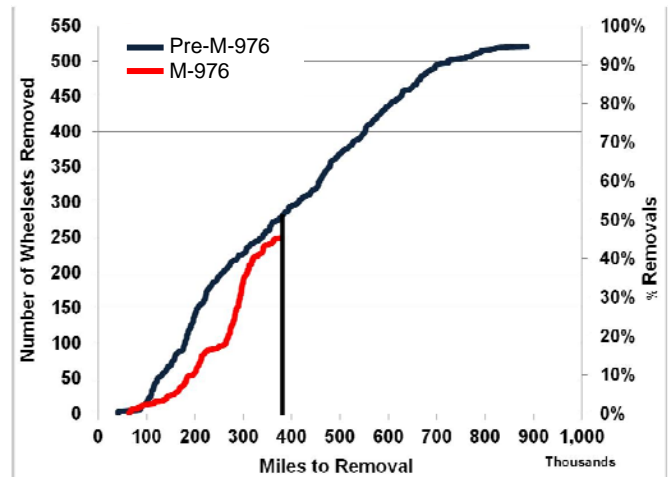


Figure 1. Comparison of Miles to Removal for Two Car Groups

Ninety-six percent of wheelsets have been removed from cars in Group 1 after 886,830 miles in service. The maximum wheelset mileage at removal for Group 2 is 380,000 miles.

This TD compares both groups up to 380,000 miles in service, and Table 2 summarizes wheel removals at this mileage.

Wheel removals due to tread damage have declined by a factor of 3.5 in Group 2. However, wheel removals due to thin flange have increased by a factor of 3.9 resulting in a limited reduction (5 percent) in the number of wheels removed up to 380,000 miles in service.

Table 2. Number and Percent of Wheelsets Removed at 380,000 Miles in Service according to Four Removal Groupings

	Group 1 (Pre-M-976)		Group 2 (Post-M-976)	
	Number Removed	Percent	Number Removed	Percent
Thin Flange	44	8%	172	32%
Tread Damage	218	40%	62	11%
Slid Flat	8	1%	6	1%
“Other”	9	1%	4	1%
Total	279	50%	244	45%

Miles to Wheelset Removal for Tread Damage

Figure 2 shows the miles to removal for tread damage (fatigue) related reasons for both groups.

The data indicates that not only has the number of wheel removals due to tread damage decreased by a factor of 3.5 (Table 2), but the rate of wheel removals has decreased by a factor of between 4 and 6 (see difference in slope of linear regressions in Figure 2). Further analysis of this information per wheel position is expected to assist in more accurately defining load and fatigue limits. This work will be reported in future TDs.

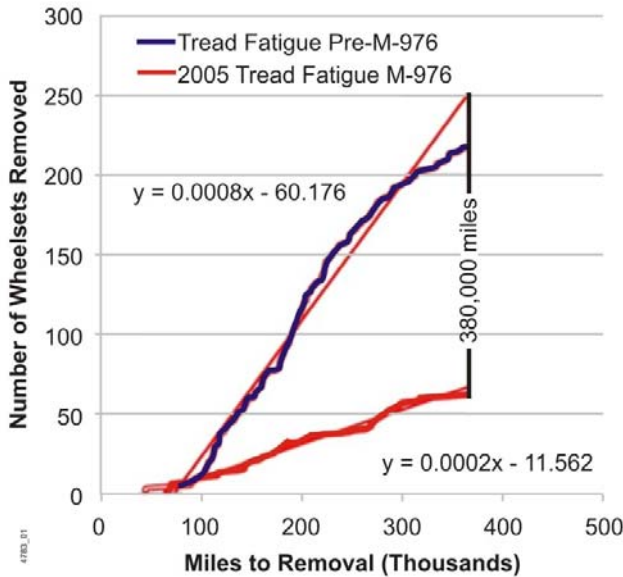


Figure 2. Comparison of Miles to Removal for Tread Damage (fatigue) Related Reasons

Miles to Wheelset Removal for Thin Flanges

Figure 3 compares the wheel removal rates for thin flanges. Wheel removals for thin flange commence for both groups after approximately 100,000 miles of service. The rate of thin flange wheel removals for Group 2 accelerates after approximately 180,000 miles of service beyond the rate experienced by Group 1 cars. This supports contentions of coal car owners and operators of an increase in this cause for wheel removal.

The trend line of tread damage wheel removals for pre-M-976 cars depicted in Figure 2 is superimposed on Figure 3 together with a line of similar slope approximating thin flange wheel removals. The mileage difference between these two trend lines is 80,000 miles. This suggests that the increase in life due to removal for tread damage afforded by the M-976 truck is now limited by thin flange wheel removals and that this increase is, for this car type and service condition, approximately 80,000 miles.

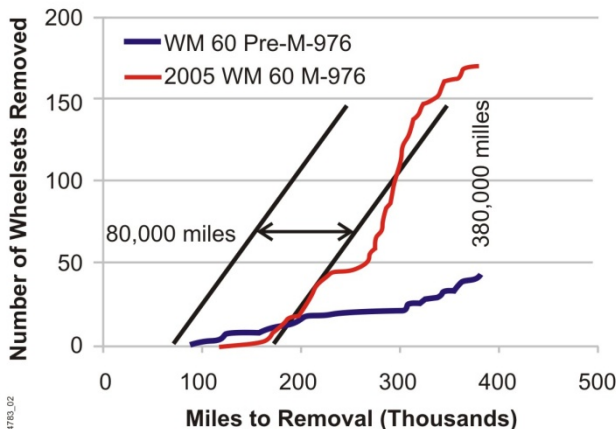


Figure 3. Comparison of Miles to Removal for Thin Flanges

Thin flange wheel removals attributed to Group 2 cars are the main driver of wheel removals to the levels experienced by Group 1 cars.

Miles to Wheelset Removal for Other Causes

Table 2 shows the relative insignificance of slid flat and other removals; this data is not shown graphically.

WHEEL REMOVALS ACCORDING TO WHEEL LOCATION IN THE CAR

Removals were examined for the frequency of removal according to wheel location in the car.

Tread Damage Wheelset Removals

Figure 4 compares tread damage (fatigue) wheel removals between the two groups.

In Group 1, tread damage wheel removals on axles 2 and 4 dominate the removals, which suggests that the cars may have been running predominantly with the A-end leading.

Removals for tread damage on axle 2 are 65 percent of those for axle 4. The lead axle of the trail truck of a 2-truck car experiences reduced forces above those of the lead axle of the lead truck.

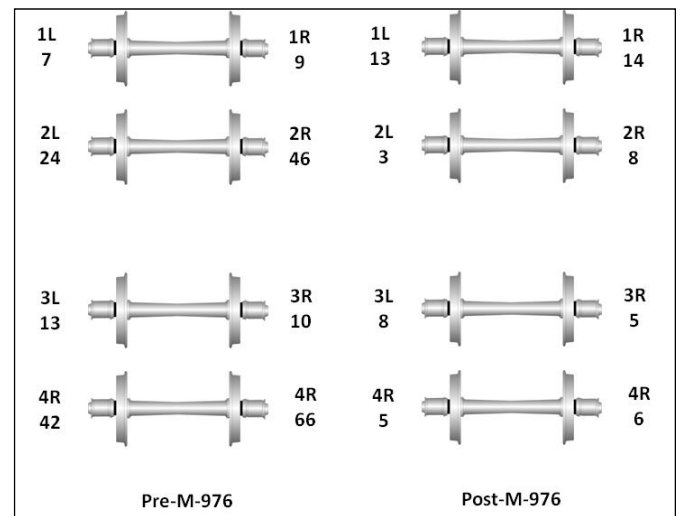


Figure 4. Comparison between Groups 1 and 2 on the Location of Wheelset Removals for Tread Damage

Group 2 shows no appreciable bias in tread damage between wheels on axles 1 through 4. This suggests improved steering on the lead axles irrespective of running direction.

Thin Flange Wheelset Removals

Figure 5 shows the pattern of thin flange wheel removals in both car groups. The rate of wheel removals and diagonal eccentricity is less than that seen in previous studies relating these removals to asymmetric wheel wear.^{3,4} Investigations continue to better understand the root causes of the diagonal basis of thin flange wheel removals and asymmetric wheel flange wear.

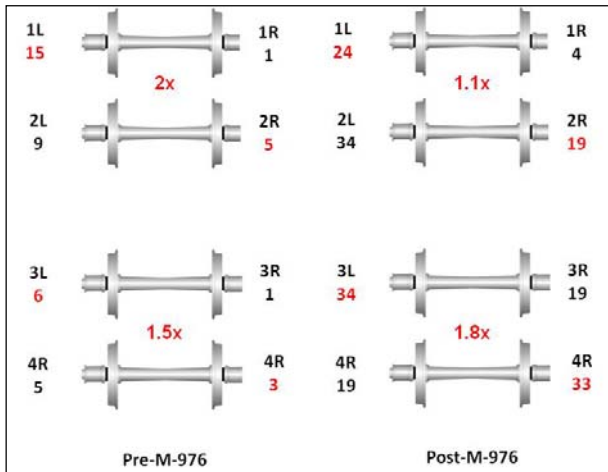


Figure 5. Comparison between Groups 1 and 2 on the Location of Wheelset Removals for Thin Flanges

NET IMPROVEMENT IN LIFE OF WHEELS REMOVED

Given the improvement in wheel tread life associated with the M-976 truck countered by the increase in thin flange wheel removals, is there a net benefit to the car owner?

Referencing Table 3, for all wheels removed up to 380,000 miles in service:

- The wheelset-miles and wheelsets removed were determined per removal type.
- The wheelset-miles for wheelsets removed for each group was summed and divided by the number of wheels removed.
- This provides the average wheelset life in miles per wheelset removed.

Notwithstanding the increase in WM 60 wheel removals, it appears that there has been a net improvement of 17 percent in the average life of wheels removed.

Table 3. Determination of Net Benefit of M-976 Trucks

	Group 1 (Pre-M-976)		Group 2 (Post-M-976)	
	Wheelset Miles (million)	N ^o of Wheelsets Removed	Wheelset Miles (million)	N ^o of Wheelsets Removed
Thin Flange	11.137	44	46.964	172
Tread Damage	43.665	218	12.497	62
Slid Flat	2.268	8	1.016	6
“Other”	2.433	9	1.007	4
Total	59.503	279	61.485	244
Miles/Wheelset Removed	214,812 miles		251,986 miles	
Net Improvement	17 %			

CONCLUSIONS

A comparison between revenue service wheel-life data from two train sets, one fitted with 3-piece trucks and the other fitted with M-976 trucks, indicates an improvement in average wheel life to removal of 17 percent after 380,000 miles.

The improvement is attributable to a 3.5 times reduction in the number of wheelsets removed for tread damage on cars fitted with M-976 trucks, which is attributed to the improved steering of the M-976 truck. There may be further benefit to be derived from further improving M-976 truck steering and eliminating all removals for tread damage.

The incidence of tread damage on 3-piece trucks in Group 1 is higher than that in a similar survey of cars fitted with 3-piece trucks in western coal service, although that of Group 2 cars (M-976 trucks) is remarkably similar.⁴ The improvement in average wheel life however was limited by a 6.6-fold increase in WM 60 (thin flange) wheel removals associated with asymmetric tread wear.^{3,4} This suggests that every effort must be made to reduce WM 60 (thin flange) wheel removals in high mileage coal car operation in order to take advantage of the reduction in WM 65 (high impact wheel) wheel removals associated with the M-976 truck.

The level of diagonal bias of thin flange wheel removals for both groups is lower than observed in previous analyses of coal cars fitted with body-mounted brake rigging and associated with asymmetric wheel flange wear.^{3,4} In addition, the higher incidence of thin flange wheel removals at lower mileages needs to be explained. Details of the specific routes, brake rigging and brake beam guides will be sought to shed further light on this issue.

The magnitude of the improvement in tread damage wheel removals observed suggests the dominance of steering tractions in determining wheel performance in western coal operation. It might suggest that stuck brakes resulting in overheated wheels and slid flats may not be a large factor.

These conclusions are based on limited in-service performance data from two groups of cars in western unit train coal service. More performance data is being sourced to:

- Better understand the role of reduced steering tractions in improving wheel tread performance
- Investigate the performance of M-976 trucks in eastern coal and other services
- Better understand the root causes for asymmetric wheel flange wear and its role in limiting wheel life improvements

Results will be published in future TDs.

ACKNOWLEDGEMENTS

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