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Wheel Life Comparison 3-Piece versus M-976 Trucks

Analysis Case B: 809 versus 124 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, one fitted with 3-piece trucks and the other fitted with M-976 trucks, indicates a net improvement of wheelset miles to removal of 24 percent after 590,000 car service miles.

This improvement is attributed to a 2.8 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 6.5-fold increase in thin flange removals and emphasizes the need to find a solution to asymmetric wheel wear associated with premature thin flange removals.

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 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.

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INTRODUCTION

TTCI was tasked, through the Association of American Railroads' (AAR) Strategic Research Initiatives Program, to develop truck designs to improve current performance. 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.

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. This could compromise gains due to HIW reduction.

Analysis of the service life of wheelsets fitted to M-976 and pre-M-976 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 removals and suggest causes for these removals.

This *Technology Digest* (TD) reports on a comparison of wheelset removals from two groups of 286,000-pound capacity coal cars operating on a western railroad: one group of 809 cars is equipped with standard 3-piece trucks and the other, a single train, is equipped with M-976 trucks. TTCI understands that both groups operated on substantially 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:	809	124
Build Date:	2000	2005
Truck Type:	3-piece, constant damped	Split wedge, rubber adapter pads
Miles in Service	978,000 miles	490,000 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 only 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)

The number of wheelsets removed from cars in Group 1 (pre-M-976) was then "scaled" by a factor of 124 cars/809 cars to allow comparison with the number of removals in Group 2 (post-M-976).

Miles to Wheelset Removal

Figure 1 shows all wheelset removal data sorted in ascending miles to removal.

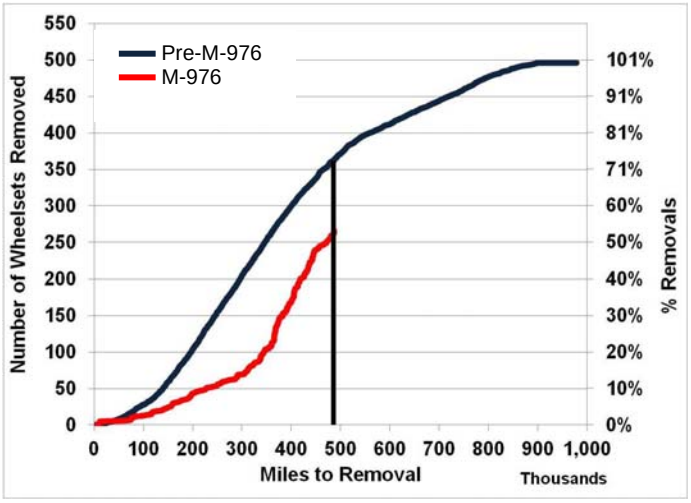

Figure 1. Comparison of Miles to Removal for Two Car Groups

One-hundred percent of wheelsets have been removed from cars in Group 1 after 978,000 miles in service. The maximum wheelset mileage for Group 2 is 490,000 miles.

This TD compares both groups up to 490,000 miles in service, and Table 2 summarizes wheel removals at this mileage.

Tread damage has declined in Group 2, and thin flange removals have increased.

Table 2. Number and Percent of Wheelsets Removed at 490,000 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	21	4%	138	28%
Tread Damage	276	56%	96	19%
Slid Flat	5	1%	10	2%
"Other"	60	12%	22	4%
Total	**362**	**73%**	**266**	**54%**

Miles to Removal for Tread Damage

Figure 2 shows the miles to removal for tread damage for both groups.

The data indicates that not only has the number of removals for Group 2 (M-976 trucks) decreased by a factor of 2.8 (Table 2), but the rate of removals has decreased by a factor of between 3 and 4 (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.

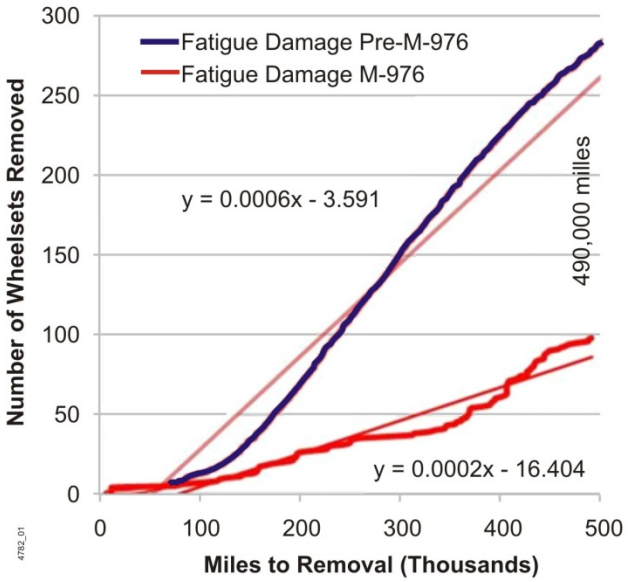

Figure 2. Comparison of Miles to Removal for Tread Damage (Fatigue) Related Reasons

Miles to Removal for Thin Flanges

Figure 3 compares the removal rates for thin flanges. Removals commence for both groups after approximately 200,000 miles in service. The rate of thin flange removals for Group 2 accelerates after approximately 250,000 to 300,000 miles in service beyond the rate experienced by cars in Group 1. This supports contentions of coal car owners and operators of an increase in this removal mode for M-976 trucks.

The trend line of tread damage 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 removals. The difference between these two trend lines is 180,000 miles. This suggests that the increase in life to removal for tread damage afforded by the M-976 truck is now limited by thin flange removals and that this increase is, for this car type and service condition, approximately 180,000 miles.

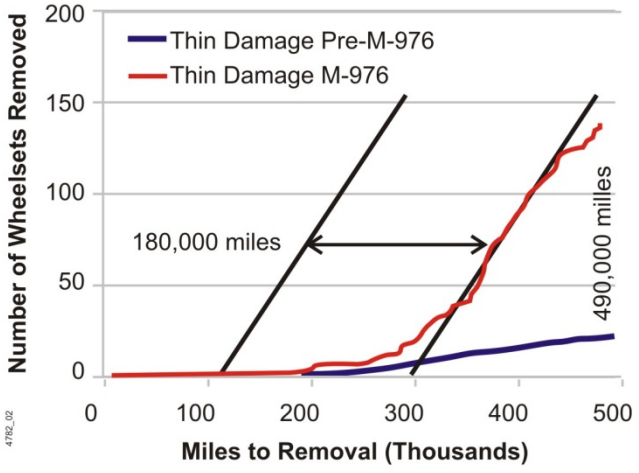

Figure 3. Comparison of Miles to Removal for Thin Flanges

Miles to Removal for Other Causes

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

Other removals have reduced by a factor of 2.5. This is almost entirely due to the elimination of WM 74 (thermal crack) removals. There was the equivalent of 42 WM 74 wheel removals per 124 cars for Group 1 cars in the first 480,000 miles in service. None was reported for Group 2 in the first 480,000 miles in service. The reason for this decline in WM 74 removals is unknown.

REMOVALS ACCORDING TO WHEEL LOCATION IN CAR

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

Tread Damage

Figure 4 compares tread damage (fatigue) removals between the two groups. In Group 1, tread damage removals on axles 1 and 4 are 72 percent higher than on axles 2 and 3. This may be expected, since the lead axle of the trail truck of a 2-truck car generally experiences reduced forces above those of the lead axle of the lead truck. With the car operated equally in both directions of travel (A- and B-end lead), this difference should be apparent; it is also symmetric, end-to-end in the car, as might be expected if the cars are operated equal distances in each direction.

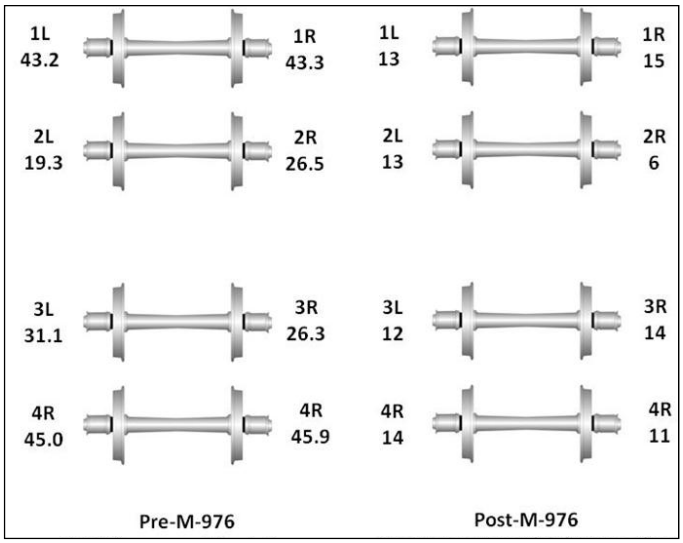

Figure 4. Comparison between Groups 1 and 2 on the Location of Wheelset Removals for Tread Damage

The difference between axles 1 and 4 and 2 and 3 is reduced to 17 percent for the cars in Group 2. This is a consequence of the large reduction in removals of axles 1 and 4 between Groups 1 and 3 and suggests expected reduced steering forces on the lead axles of the M-976 trucks.

Thin Flange Removals

Figure 5 shows the pattern of thin flange removals in both car groups. The rate of removals and diagonal eccentricity has increased tending to confirm studies relating these removals to asymmetric wheel wear.[3]

Investigations into the root causes for asymmetric wheel flange wear continue and will be reported in future TDs.

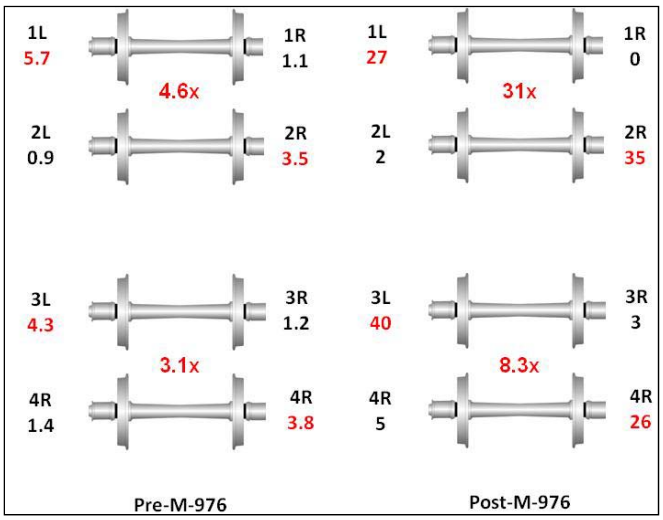

Figure 5. Comparison between Groups 1 and 2 on the Location of Wheelset Removals for Thin Flanges

NET IMPROVEMENT IN LIFE OF WHEELS REMOVED

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

Referencing Table 3, for all wheels removed up to 490,000 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/wheelset removed.

Table 3. Determination of Net Benefit of M-976 Trucks (revised table; revisions noted in red)

	Group 1 (Pre-M-976)		Group 2 (Post-M-976)	
	Wheelset Miles (Millions)	No. of Wheelsets Removed	Wheelset Miles (Millions)	No. of Wheelsets Removed
Thin Flange	7.159	21	51.755	138
Tread Damage	79,419	278	29.998	96
Slid Flat	0.969	5	2.134	10
"Other"	13.376	60	6.453	22
Total	100.923	364	90.36	266
Miles/ Wheelsets Removed	277,261		339,699	
Net Improvement	22.5%			

Consequently, notwithstanding the increase in WM 60 removals, there has been a net improvement of 24 percent in the average life of wheels removed.

CONCLUSIONS

A comparison between revenue service wheel life data from car groups, one fitted with 3-piece trucks and the other fitted with M-976 trucks, indicates an improvement in average wheel life to removal of 24 percent after each consist has run 490,000 miles.

The improvement is attributed to a 2.8 times reduction in the number of wheelsets removed for tread damage on cars fitted with M-976 trucks; this is attributed in turn to the improved steering of the M-976 truck.

This improvement in average wheel life is limited by a 6.5-fold increase in WM 60 (thin flange) removals. These removals have been associated with asymmetric tread wear.[3] This suggests that every effort must be made to reduce WM 60 (thin flange) removals in high mileage coal car operation in order to take advantage of the reduction in WM 65 (high impact wheel) removals. It also suggests that there may be further benefit to be derived from further improving M-976 truck steering and eliminating all removals for tread damage.

The magnitude of the improvement in tread damage 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 wear and its role in limiting wheel life improvements.

Results will be published in future TDs.

ACKNOWLEDGEMENTS

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