TTCI TECHNOLOGY DIGEST

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# Assessment of Service-Worn, 110-ton M-976 Trucks

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## Key Findings:

- Of the examined service-worn M-976 trucks, all had some components worn to prescribed limits, but in most cases this wear was not apparent until disassembly.
- The worn trucks that were tested did not meet many of the M-976 performance criteria for new trucks in dynamic response test regimes.
- Truck-caused derailment rate is statistically lower in M-976 fleet than in the non-M-976 fleet of cars built during the same years (2003–2017).
- It is desirable to test several M-976 trucks, worn to the prescribed limit based on wedge rise, should they become available.
- Improper truck rotation is the most common cause of truck-related derailments in either M-976 and non-M-976 trucks built between 2003 and 2017. The root cause and the potential solutions to this issue should be investigated.
- It is recommended that the statistical analysis of truck-caused derailments is repeated in 3 to 5 years when M-976 railcars acquire longer time in service.

Transportation Technology Center, Inc. (TTCI) conducted a series of measurements, tests, and analyses on 12 service-worn, 110-ton M-976 freight trucks built by two different manufacturers with mileage ranging from 525,000 to 826,000. The goal of the study was to assess the effects of wear on performance of M-976 trucks. This research was performed as a part of the Association of American Railroads' (AAR) Strategic Research Initiatives (SRI) program. Complete results of this study can be found in previously published AAR research reports.[1,2]

## BACKGROUND

It is known that truck wear can affect the dynamic performance of three-piece trucks, especially when subjected to track irregularities.[3–5] Since the adoption of AAR Specification M-976[6] in 2002, eight truck systems have been approved under this specification.[7] When these trucks are being taken out of service to be rebuilt under railroads' planned maintenance programs, an opportunity arises for assessing how wear affects the performance of these service-worn trucks.

## PROCEDURE

The study consisted of the following steps:

1. Field measurement of worn M-976 trucks and selection of candidates for further assessment.
2. Disassembly and detailed measurements of truck components to quantify wear. Percentage wear was estimated based on components' dimensions, AAR Specification M-214,[8] and the AAR *Field Manual of Interchange Rules*,[7] where applicable. Because nominal component dimensions were used in some of the wear calculations, some of the estimated wear may in fact be due to manufacturing tolerances.
3. Assessing trucks' dynamic performance by testing of selected trucks against a subset of M-976 test regimes.[4]
4. Analysis of data from the Umler® system[9] and the FRA Accident/Incident Database[10] to identify trends and compare performance of M-976 and non-M-976 fleet operating in revenue service.

## RESULTS

### Truck Selection and Field Measurements

TTCI contacted two Class I railroads and a private car owner to help identify and obtain M-976 approved trucks from high-mileage railcars.

A total of 26 of railcars with 286,000 pounds gross rail load (GRL) were identified as candidates for further examination. Their truck side wedge rise was measured as a proxy indicator for overall truck wear, and percentage wear was calculated (Table 1). No significant correlation was found between mileage and estimated percentage wear.

Maintenance records were examined to verify that no major truck component repairs or replacements, other than wheelsets, have recently been made. Based on a combination of mileage, wedge rise, and maintenance records, six car sets (12 trucks) were selected for further assessment and testing. Two sets had trucks of model A and four had trucks of model B. These sets are highlighted in Table 1.

**Table 1. Wedge rise measurements**

| Car No. | Type | Mileage | Truck Model | Truck side wedge rise (% of prescribed limit) | | | |
|---|---|---|---|---|---|---|---|
| | | | | BL | BR | AL | AR |
| 492 | Refriger-ated boxcars | 402,326 | A | 33% | 15% | 35% | 15% |
| 115 | | 448,563 | | 50% | 50% | 33% | 50% |
| 071 | | 467,394 | | 48% | 46% | 71% | 37% |
| 074 | | 476,173 | | 54% | 46% | 46% | 48% |
| 480 | | 525,786 | | 67% | 44% | 108% | 92% |
| 212 | | 540,604 | | 33% | 15% | 44% | 46% |
| 472 | | 550,854 | | 29% | 29% | 52% | 63% |
| 313 | | 571,012 | | 42% | 52% | 37% | 37% |
| 482 | | 649,570 | | 25% | 8% | 23% | 21% |
| 308 | | 655,458 | | 50% | 50% | 37% | 56% |
| 079 | | 657,941 | | 42% | 63% | 63% | 50% |
| 424 | | 667,869 | | 31% | 23% | 33% | 37% |
| 484 | | 713,683 | | 25% | 21% | 27% | 13% |
| 326 | Grain hoppers | 609,000 | B | 38% | 25% | 25% | 38% |
| 008 | | 615,000 | | 38% | 25% | 31% | 38% |
| 084 | | 624,000 | | 19% | 25% | 28% | 44% |
| 262 | | 632,000 | | 50% | 38% | 31% | 44% |
| 927 | | 641,000 | | 38% | 31% | 25% | 38% |
| 063 | | 654,000 | | 38% | 25% | 38% | 50% |
| 091 | | 655,000 | | 50% | 38% | 25% | 38% |
| 366 | | 660,000 | | 50% | 31% | 31% | 44% |
| 015 | | 661,000 | | 50% | 25% | 31% | 50% |
| 270 | | 677,000 | | 50% | 38% | 38% | 38% |
| 012 | | 693,000 | | 38% | 44% | 50% | 56% |
| 721 | Coal gondolas | 832,350 | B | 44% | 31% | 36% | 44% |
| 702 | | 886,600 | | 50% | 50% | 25% | 44% |

### Truck Component Wear Assessment

Tables 2 and 3 show calculated percentage wear of some of the truck components measured prior to the testing of the selected truck sets.

**Table 2. Estimated wear of bearing adapters and pedestal lug surfaces**

| Set No. | Bearing adapter reaction surface wear | | Pedestal thrust lugs lateral wear | | Pedestal thrust lugs longitudinal wear | |
|---|---|---|---|---|---|---|
| | Avg. | Max | Avg. | Max | Avg. | Max |
| 072 | 61% | 154% | 37% | 55% | 41% | 66% |
| 080 | 56% | 176% | 69% | 340% | 40% | 66% |
| 012 | 0% | 0% | 69% | 86% | 26% | 36% |
| 015 | 0% | 0% | 68% | 107% | 36% | 42% |
| 702 | 0% | 0% | 32% | 54% | 50% | 63% |
| 721 | 0% | 0% | 24% | 46% | 63% | 83% |

**Table 3. Estimated wear of truck frictional surfaces**

| Set No. | Pocket lateral wear | | Bolster slope wear | | Wedge face wear | | Column wear plate wear | |
|---|---|---|---|---|---|---|---|---|
| | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 072 | 200% | 265% | 50% | 117% | 34% | 56% | 69% | 100% |
| 080 | 118% | 170% | 29% | 33% | 66% | 100% | 63% | 100% |
| 012 | 47% | 95% | 183% | 233% | 51% | 80% | 59% | 100% |
| 015 | 27% | 34% | 158% | 283% | 52% | 76% | 63% | 75% |
| 702 | 39% | 54% | 113% | 167% | 29% | 44% | 49% | 58% |
| 721 | 52% | 90% | 81% | 133% | 31% | 42% | 67% | 82% |

**Springs:** In 5 out of 12 trucks, all springs were intact. Each of the remaining seven trucks had one to three broken springs — mostly inner main coils or inner control coils. The unbroken springs' free lengths met the requirements of the AAR Interchange Rules (Rule 50). The broken springs were replaced prior to testing in order to isolate the effects of wear from the effects of broken components.

**Center bowls:** Two truck sets (Nos. 472 and 480) used metal center bowl liners with lubricating disks, which were heavily worn. Two other sets (Nos. 012 and 015) had non-metal horizontal liners and metal vertical liners. The liner of the B-end truck of set No. 015 was lost during transport and replaced with one from set No. 012. The liner was rotated from its original orientation when installed in set No. 015. The remaining two sets (Nos. 702 and 721) used a cup-type non-metal liner whose edges became significantly deformed in places where center plate chamfer contacts the liner (Figure 1a). Center bowl wear, as estimated from diameter measurements, was minimal.

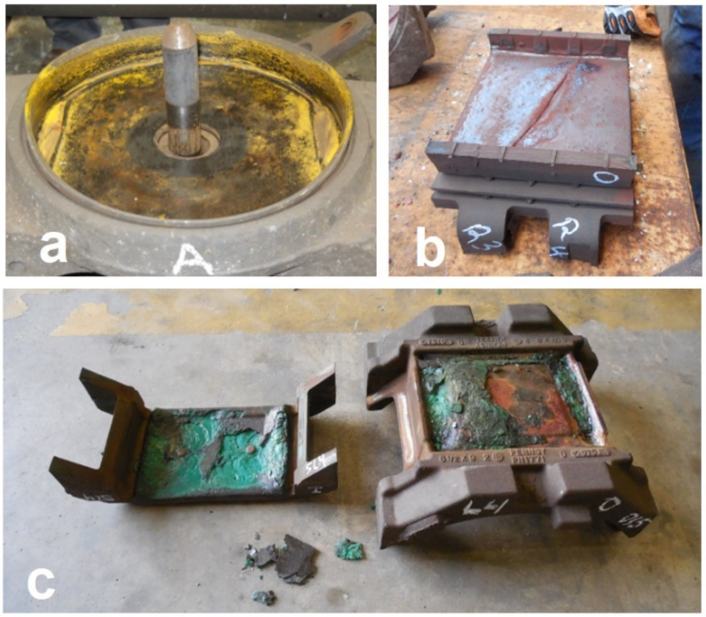


Figure 1. a) Worn center bowl liner; b) cracked adapter pad; c) delaminating adapter pad

**Side frame columns.** On all examined trucks, the wear on side frame column lateral surfaces was below the prescribed limits.

**Bearing adapters and pedestal thrust lugs.** One shear pad had a crack in the elastomeric material (Figure 1b). Two trucks (both from the same car set) revealed partial delamination in four adapter pads (Figure 1c).

Trucks that had adapter pads whose design prevented a direct contact between bearing adapters and pedestal thrust lugs were showing no wear on the bearing adapters. Wear on the pedestal thrust lugs on these trucks was below condemnable limits, except for one side frame. Trucks with elastomeric adapter pads that allowed metal to metal contact were generally showing more wear on bearing adapters and on thrust lugs (Table 2).

**Frictional surfaces.** Table 3 shows the wear on the frictional elements of the truck: friction wedge faces, column wear plates, bolster slope surface, and bolster pockets. All of the trucks tested were showing wear on one or more of these surfaces exceeding the prescribed limit, even though truck side wedge rise was below the limit.

Two of the trucks showed an unusual contact between the bolster pockets and the wedge spring seats. The truck manufacturer stated that the tolerances have been changed to prevent this contact in the more recently manufactured trucks.

## Testing of Truck Sets

Several of the trucks from the sets described earlier were tested under selected M-976 testing regimes (Table 4). The trucks tested include truck sets Nos. 072, 080, 015, and a set made of No. 702 B-end truck and No. 721 A-end truck.

Table 4. Results of truck set testing under M-976 regimes

| Set No. | Speeds at which M-976 criteria are not met (mph) (E = Empty car, L = Loaded car) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pitch & Bounce | | Twist & Roll | | Dynamic Curving* | Hunting** | |
| | E | L | E | L | L | E | L |
| 072 | None | ≥61 | 20-28 | 13-14 | 14-16 | ≥75 | ≥55 |
| 080 | None | ≥58 | 20 | 14 | 16 | ≥65 | ≥55 |
| 015 | Not tested | ≥52 | Not tested | 14 | 10-18 | ≥73 | ≥59 |
| 702/721 | | ≥51 | | 11 | 10-15 | ≥60 | ≥51 |

* Dynamic Curving criteria include preponderance of vertical wheel loads over a speed range (Specification M-976, §4.1.2.5.4). Not meeting criteria at a certain speed does not always mean not meeting Specification M-976.

** Specification M-976 does not require Hunting tests at >70 mph.

All tested truck sets did not meet some of M-976 criteria in twist and roll (loaded car), pitch and bounce (loaded car), and hunting (loaded car) testing regimes. Some of the truck sets did not meet the criteria in twist and roll (empty car) and hunting (empty car) regimes.

Under the Dynamic Curving test regime, all truck sets did not meet criteria at certain test speeds, but set No. 080 met the M-976 criteria for the testing regime as a whole, while set No. 702/721 did not. Testing of sets Nos. 072 and 015 was interrupted due to safety concerns (significant wheel unloading in set No. 072 and poor steering in set No. 015, the latter likely due to center bowl liner condition discussed previously).

## FRA Accident/Incident Database Derailment Analysis

Analysis of data from the Umler® system showed that 231,768 M-976 cars and 315,326 non-M-976 cars with GRL of 286,000 pounds were built between 2003 and 2017. A query into the FRA Incident/Accident database was made to determine how many of these railcars were involved in derailments due to truck-related causes (improper truck rotation, defective snubbing, truck hunting, and other truck component defects), and how long each of these cars was in service at the time of derailment.

Analysis showed that between 2003 and 2017 there were 20 truck-caused derailments (seven on main track, 10 on yard track, one on siding, and two on industry track) involving non-

M-976 cars and four such derailments (two on main track, one on yard track, and one on industry track) involving M-976 cars. Improper truck rotation was the most common cause of truck-caused derailments in either group.

Figure 2 shows the survival plot of the two car populations (percentage of cars that have not derailed from truck-related causes as a function of their years in service). A right-censored non-parametric survival analysis of the data showed that amongst the cars built between 2003 and 2017, M-976 cars had lower rate of truck-caused derailments than non-M-976 cars, statistically significant at a 95% confidence level.

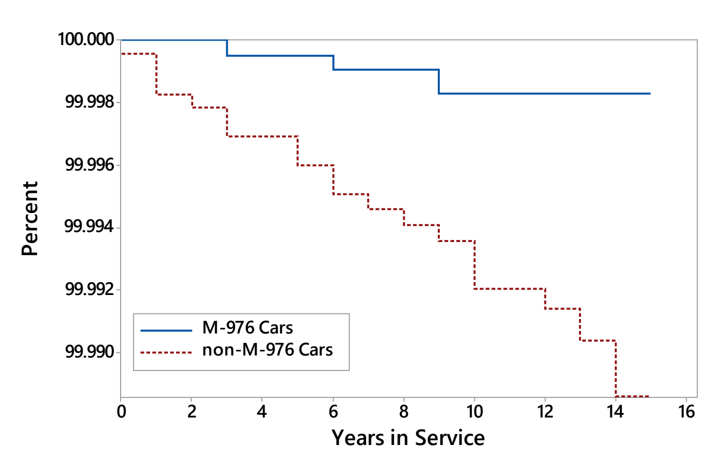


**Figure 2. Survival plot for M-976 and non-M-976 cars built in 2003–2017**

## CONCLUSIONS AND RECOMMENDATIONS

All of the tested trucks had some components worn to prescribed limits, but in most cases this wear was not apparent until disassembly. The worn trucks did not meet many of the M-976 performance criteria for new trucks in dynamic test regimes. However, the rate of truck-caused derailments is lower in the M-976 fleet than in the non-M-976 fleet built during the same years.

It is desirable to test several M-976 trucks which are worn to the prescribed limit based on wedge rise, should they become available; testing should focus on assessing whether there is suspension binding or other severe degradation of performance in curving and hunting regimes. Results of this further testing can be used to assess whether the existing limits for wedge rise are appropriate.

Since truck-caused derailments are very rare in both M-976 and non-M-976 cars, and the M-976 car population is still relatively young, the derailment statistics and their confidence intervals are very sensitive to the studied time interval. It is recommended that this statistical analysis is repeated in 3 to 5 years when M-976 railcars acquire longer time in service to further validate current results.

The root cause and the potential solution to the issue of improper truck rotation in both M-976 and non-M-976 trucks should be investigated.

**References**


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