TECHNOLOGY DIGEST
TD-10-031
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Teardown Study of TTX Equipment Identified by Wayside Detectors

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Summary

TTX, in cooperation with the Truck Performance Detector (TPD) Technical Advisory Group, performed a teardown study specifically targeting TPD alarmed cars likely to have “no problem found” results upon field inspection.

TTX freight cars recently alarmed by a wayside detector and meeting the criteria were sent to Transportation Technology Center (TTC) for teardown and inspection.

Criteria for selecting the alarmed cars for the study were low mileage on the trucks such that wear would not likely be the cause of the alarm or cars equipped with premium truck equipment expected to perform well at the current mileage.

Cars inspected at TTC showed defects that correlated to the specific TPD alarms, but in some cases the defects were found only after a highly detailed teardown inspection was performed by experienced personnel. Reports from field inspections indicate that correlations are not always found, and it is hoped that the information presented here will assist those performing such inspections in the future.

TTX railcars pass the network of North American wayside detectors daily. Alarms and other records from these detectors provide TTX information regarding the performance of their fleet. Alarms from this network of detectors resulted in the truck teardown inspections.

By continuously evaluating and improving wayside detector algorithms and inspection techniques, railroads and car owners are improving the overall condition of the fleet and reducing stress on the infrastructure. Information gathered by teardown studies, such as this will not only improve car inspections and maintenance practices, but also assist the railroads in setting detector alarm limits.

This work was tasked by the Association of American Railroads as part of its Strategic Research Initiatives Program.

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INTRODUCTION

Over the past decade, wayside detectors installed on North American railways have grown from a handful to a few hundred. The North American network of detectors is comprised of numerous types of detectors from several vendors. They all have a common goal of identifying anomalous performing vehicles. By identifying these vehicles and repairing them, railroads and car owners are able to target their maintenance inspections and lower the stress state of the North American railway infrastructure.

To explore the possibility of current and proposed truck performance detector metrics, creating false positive alarms resulting in “no problem found” inspection reports, a selected sample of recently alarmed TTX railcars was sent to TTC for teardown and inspection.

The sample was selected from those that would most likely generate a “no problem found” inspection report and from those meeting either of two criteria: (1) low mileage, because new or rebuilt railcars have less wear therefore they are less likely to cause an alarm, and (2) cars equipped with premium trucks because they are expected to have better than average performance at their current mileage. Cars were also selected from different detector performance metrics and different detector types.

Transportation Technology Center, Inc. (TTCI) and representatives of the TPD Technical Advisory Group (TAG) provided the detector alarm history data and oversaw the teardown and inspection activities. The inspection results for the three cars selected are presented here.

WAYSIDE DETECTORS

Wayside detectors are instrumented devices placed in track structures that quantify the performance of passing cars without interference.

There are numerous types of wayside detectors. The three vehicles inspected (autorack car, boxcar and an articulated intermodal car) were identified by two detector types. The autorack car and boxcar were identified by force-based TPDs, whereas the articulated intermodal car was identified by an optical-based TPD.

Force-based TPDs use strain gages placed on each rail and are calibrated to read the vertical and lateral forces generated on the rail by the wheels of the railcar as they pass over the detector. These force readings are then recorded, processed, and displayed in performance metrics.

Optical-base detectors use one or more lasers to measure the displacement and geometry of wheels during operation on tangent track. These measurements are also recorded, processed, and then displayed in performance metrics.

ALARMS

Each wayside detector type has several alarms metrics. Each of the identified anomalous vehicles in this study was alarmed by different performance metrics.

The autorack car alarmed for an eccentric load warp index (ELWI). The ELWI metric is generated by a force-based detector and is an indicator of an eccentric vertical wheel load pattern combined with a measure of truck warp. Historically, an eccentric wheel load pattern can be caused by carbody twist or side to side load imbalance.

The boxcar alarmed for an excessively high truck gage spread force (TGSF). The TGSF metric is also generated by a force-based detector and is defined as the force applied to both the high and low rails and directed to widen the track gage, as Figure 1 shows. If these forces are sufficiently high, they can result in rail rollover and/or gage spread of the rails. The derivation of TGSF metric can be found in the appendix of AAR/TTCI research report R-977.[1]

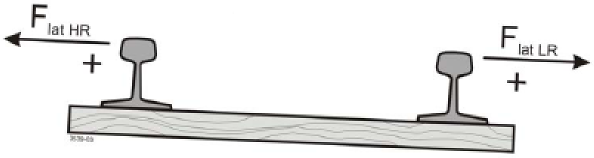

Figure 1. Gage Spread

The articulated intermodal car alarmed for excessive tracking error (TE). TE is generated by an optical-based detector and is a linear measurement of lateral distance between the tracking positions of each axle in a truck relative to the centerline of the track.[2] Figure 2 shows an example of lateral position and TE on tangent track.

Historically trucks that have alarmed for TE have had thin flanges and asymmetric wear. Through the teardown and inspection process on cars with extreme tracking positions, CSX has been successful cataloged many of these cases.[3]

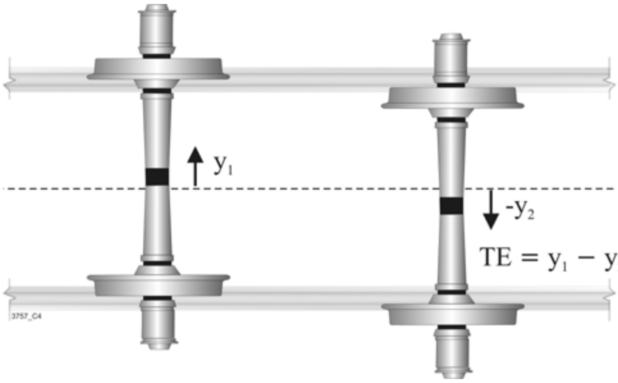

Figure 2. Tracking Error

INSPECTION AND TEARDOWNS

Three types of TTX cars — a bi-level autorack car, a 60-foot, 100-ton capacity boxcar, and a 5-unit articulated, all-purpose spine car — were inspected at TTC in January 2010. The general inspection procedure began with a visual inspection of the car in the as-received condition, recording friction wedge rise and side bearing set-up heights on all trucks, followed by jacking the cars and removing the alarmed trucks for teardown, inspection, and gaging.

Autorack Cars

The bi-level autorack alarmed for ELWI of the B-end truck in February 2008. Visual inspection of the as-received car revealed a slight twist in the car structure. This was verified by measures of the deck height relative to shop floor which showed the B-end left (BL) and A-end right (AR) corners of the deck were lower than the BR and AL corners of the deck. Also, the BL and AR side bearings each had lower set-up heights of 4 3/4 inches compared to 5 1/16 inches and 5 inches for the BR and AL side bearings, respectively.

The autorack car was equipped with 70-ton capacity Ride Control trucks with AR-1 steering arms designed to increase truck warp resistance while permitting axle radial alignment in curves. Figure 3 shows the disassembled AR-1 steering arms. The AR1 steering arms connect through the bolster lightning holes and bolt on to each of the four bearing adapters.

Figure 3. Autorack — Disassembled AR1 Steering Arms with Bearing Adapters Bolted in Place

A review of car repair billing data for this autorack car showed that in May 2009, both of the constant-contact side bearings on truck B were replaced because one bearing was worn out and the other bearing was broken.

There was no evidence of recent shim adjustment on any of the bearing wear plates on this car. The side bearing work in May was likely in response to a truck hunting index of 0.14 recorded in March 2009. During the car inspection at TTC, asymmetrical wear was found on the side bearing caps of truck B. Figure 4 shows the asymmetrical wear. It is believed by the inspectors that the low side bearing set-up heights on opposite corners of the car caused the ELWI alarm.

It appeared that the new side bearing caps and pads were installed without properly adjusting the side bearing set-up heights. Also, if the carbody twist is sufficient to prevent proper adjustment of side bearing set-up height, then the carbody needs to be straightened.

Figure 4. Autorack — Asymmetric Side Bearing Wear

Boxcar

The 60 foot 100-ton capacity boxcar alarmed for a TGSF exceeding 30,000 pounds on the A-end truck in July 2008. The boxcar was equipped with S-2-HD trucks with split wedge friction castings.

Measurements of the disassembled side frames indicated that the A-end truck side frames were mismatched. The buttons of the side frame agreed, but when the outer thrust lug distance was measured on each side frame, the buttons were found to differ by 0.25 inch in length. This is equivalent to matching a 6-button side frame to a 3-button side frame. By AAR Interchange Rules the side frame must be within 1 button of each other.[4]

The car had approximately 200,000 service miles at the time of inspection and all side frames appeared to be original to the car. A review of car repair billing data revealed no replacements of side frames or other truck castings. The A-end side frame mismatch is believed to be the cause of the TGSF alarm, and the mismatch has likely existed since the car was built.

Articulated Car

The five-unit articulated all-purpose spine car was alarmed by an optical-based detector for a TE of 37.3 millimeters (1.74 inch) on Truck F. This car was equipped with 70-ton capacity S-2-C trucks with split wedge friction castings. The inspection showed that the side frames were mismatched by 1/8 inch, with the right side frame being longer and the wheels on axle Z showing asymmetric flange wear, as Figure 5 shows.

Figure 5. Articulated Car — Asymmetric Flange Wear on the Wheels of Axle Z

Figure 6 shows the Miniprof™ profiles of the wheels of axle Z.

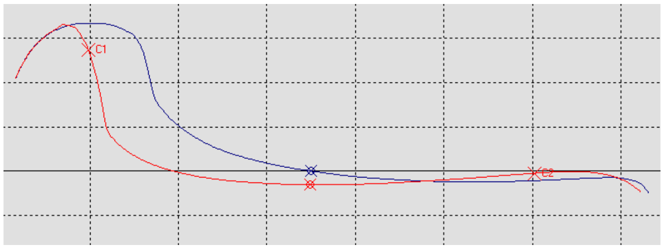

Figure 6. Articulated Car — Miniprof™ Profiles of the Wheels of Axle Z

At approximately 60,000 miles, the right wheel on the Z axle (RZ wheel) was condemnable by AAR Interchange Rules for a thin flange.[4] The previous wheelset in this location was removed for thin flange on the RZ wheel at approximately 267,000 miles.

All of the trucks on this car have been reconditioned since it was built, and the trucks have accumulated 40 percent of the mileage until the next truck rebuild is expected. This is also reflected in the general wear state of the trucks, as many dimensions were around the halfway point between the nominal new condition and the condemning limits. Interestingly, the axle Z locations had slightly more thrust lug spacing than the axle 9 locations on the two side frames, but none were at the condemning limit. The side bearing set-up heights were correct on this truck, and lubricant was present in the truck bolster bowl.

While an AAR condemnable wheel was found on the alarmed truck, this wheel condition is likely a symptom of the problem and not the cause of the alarm. While no AAR condemnable cause was found on the truck, it should be noted that the side frame mismatch was at the high end of the allowed AAR tolerance. This side frame mismatch coupled with the higher than expected thrust lug spacing for axle Z is most likely the root cause of the flange wear and detector alarm. The car owner plans to address these two issues prior to returning the car to service.

This car also shows the importance of the car owner's involvement in the TPD inspection and repair process. Only car owners or their agents can weigh the cost of inspections and precondemnable repairs against the probability of further alarms and increased wheel wear.

LEVEL OF TEARDOWN AND INSPECTION

The teardowns and inspections were performed at TTC by experienced personnel and were highly detailed in nature. It is understood that this level of inspection is not available for every truck alarm. Often the cause of the alarm is obvious or the trucks are known to be at or near the end of their maintenance cycle and are due for rebuild. Moreover, it is expected that fleet owners use TPD performance data and alarms to prioritize planned maintenance.

The intent of the TPD TAG is to not only promote better inspection methods but to also promote improved rolling stock through better TPD alarm techniques and more efficient and effective responses to those alarms.

CONCLUSION

The three cars inspected at TTC were selected for detailed inspection because they were likely to have truck problems difficult to find and not likely to have problems simply due to wear.

- The autorack car alarmed for ELWI and tight side bearings and carbody twist were found to be the causes of the alarm. Because the car had side bearing caps and spring elements recently installed and there was no evidence of side bearing height adjustments, it is likely that the car also received an improper repair.
- The boxcar alarmed for TGSF. Mismatched side frames were found to be the cause of the alarm.
- The articulated all-purpose spine car that alarmed for a TE of 37.3 millimeters(1.74 inchs) was found to have thin flange on the RZ wheel and poorly matched side frames, which was the most likely cause for the rapid flange wear and the alarm.

FUTURE WORK

Recommendations for future work include:

- Conducting on-track tests pre- and post-repair to document the dynamic performance of vehicles that may aid future TPD algorithm improvements.
- Monitoring of the three cars as they pass the wayside detector network should also be completed to ensure they are performing properly after being repaired.
- Following up with repair shops regarding proper side bearing set-up height adjustments.
- Verifying with truck casting suppliers the procedures for proper side frame pairing and button matching.

REFERENCES

1. Tournay, H. et al. July 2006. "Interpreting Truck Performance Detector Data to Establish Car and Truck Condition." Research Report R-977, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.
2. Izbinsky, G. et al. June 2006. "Monitoring Bogie Performance on Straight Track Part 1: Wheel Set Tracking Position." *The 7th World Congress on Railroad Research*, Montreal, Canada.
3. Bowling, K. 2009. "Geometry detector teardown results at CSX." RTDF2009-18026, Proceedings of 2009 Fall Conference ASME Rail Transport Division, Fort Worth, TX.
4. Association of American Railroads. 2010. *Field Manual of the AAR Interchange Rules*, Washington, D.C.