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Characterizing the Uncoupling Lever Environment During Impact Events

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Summary

Uncoupling levers are used to lift the lock in the coupler and allow the knuckle to open. For longer travel draft systems, telescoping uncoupling levers are used. These telescoping levers are designed to extend or contract with the coupler movement. All telescoping lever designs are evaluated for fitness of service by Association of American Railroads' (AAR) Specification M-961.[1] The results of the work presented in this Digest suggest that AAR M-961 could be improved by the addition of high velocity telescoping events such as car-to-car impact tests with coupler positions varied prior to coupling to increase the telescoping lever's length.

Telescoping levers are repaired more frequently per equipped car than non-telescoping levers based on car repair billing data. The majority of these levers are removed for why made code 5, bent, or why made code 6, bent beyond repair. One reason so many levers are bent is that the current specifications outlined in M-961 do not reflect telescoping speed required for the uncoupling lever during an impact event. Transportation Technology Center, Inc. (TTCI) conducted tests at the Transportation Technology Center that showed a lever may have to telescope at rates of 50 inches per second, which is significantly higher than the fatigue test rate of 15 inches per second required in AAR M-961. AAR M-961 also requires a coupling test, using a different sample than the lever used in the fatigue test, to ensure that the lever does not impede the coupling of the cars at speeds up to 8 mph. Though impact testing is required under AAR M-961, the number of cycles is not specified and it is not designed to evaluate the ability of a lever to withstand impact events. Also, AAR M-961 does not specify the position of the couplers at impact, which affects the distance the lever must extend or retract.

Testing by TTCI revealed that coupler position had the greatest effect on telescoping distance, especially in the conditions where the uncoupling lever is extended prior to impact. Speed of the coupling event, between 4 mph and 6 mph, was shown to have little effect on telescoping distance. Speed did have an effect on the acceleration of the coupler. For 4 mph runs, longitudinal coupler accelerations peaked between 20 g's and 50 g's. For 6 mph runs, longitudinal coupler accelerations peaked between 40 g's and 90 g's.

A study of Car Repair Billing information showed that cars equipped with telescoping levers are more than 3 times as likely to have multiple repairs on at least one uncoupling lever. Telescoping levers were removed mainly for why made code 5 or 6, bent or bent beyond repair. The next largest contributor was why made code 2, broken. The AAR Coupler System and Truck Castings Committee is currently reviewing the standards for uncoupling levers. The changes that need to be made to bring this standard in line with the current demands on levers will be made by incorporating results from this test and other tests.

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INTRODUCTION

TTCI evaluated the loading environment for uncoupling levers during an impact event and compared the results to the current specifications. This *Technology Digest* (TD) summarizes the approach and results from the testing conducted at the Transportation Technology Center (TTC).

Background

Based on Car Repair Billing statistics, over 1,059,000 uncoupling levers were replaced from 2006 to 2014. Uncoupling lever repairs are defined by two removal codes. Code 2480 defines removals of non-telescoping levers and Code 2482 defines removals of telescoping levers. About 576,000 non-telescoping levers were reported to Car Repair Billing between 2006 and 2014, and about 483,000 telescoping levers were reported during the same period. Seventy-four percent of telescoping levers were removed for why made code 5 or 6, bent or bent beyond repair. About 13 percent of the levers were removed for why made code 2, broken.

Approximately 483,000 repairs of telescoping levers involved 214,000 cars. Of the 214,000 cars, ~67,000 cars, or ~31 percent, had three or more repairs. For non-telescoping levers, the approximately 576,000 repairs were applied on ~402,000 cars. Of the 402,000 cars, ~37,000 cars, or ~9 percent, had three or more repairs. Comparing the repair data shows that cars equipped with telescoping levers are more than 3 times as likely to have multiple repairs on at least one uncoupling lever.

All telescoping levers are managed under AAR Specification M-961, which defines uncoupling devices that are not defined in AAR Standard S-131, AAR Standard S-133, or AAR Standard S-134.[1,2,3,4] AAR M-961 requires each design to be tested and validated for service. It calls for a durability test of 100,000 cycles. The frequency for the lever is between 15 and 17 cycles per minute. If one assumes a cycle is 50 inches of travel, the telescoping rate is between 12.5 inches per second and 14.2 inches per second. During the first 600 cycles, a sand slurry is poured over the lever periodically to simulate severe environmental conditions. Using a different sample than the lever used in the fatigue testing, impact tests are conducted to ensure that the lever does not impede the coupling of the cars at speeds up to 8 mph.[1]

Though impact testing is required under AAR M-961, the number of cycles is not specified and it is not designed to evaluate the lever's ability to withstand impact events. The position of the couplers at impact is also not specified. Altering the coupler positions will greatly affect the telescoping requirements of the lever at impact.

Test Setup

Testing was conducted on the Precision Test Track (PTT) at the TTC. A box car and anvil string of loaded hopper cars were used to simulate the impacts that occur in hump yards. Figure 1 shows these cars positioned before testing. The equipment on the car was inspected for defects. No defects were found and the original equipment remained on the car. The age and service life of the uncoupling lever could not be determined; however, the lever was considered to be representative of a typical lever in service.

Handbrakes were used to secure the cars on the PTT. The PTT has a downhill grade that can be used to create impacts at a range of speeds. One car was released up-track from the stationary cars to create the impacts at target speeds varying between 4 mph and 6 mph.

Figure 1. Stationary Test Car and Anvil String

Coupler positions were varied to increase the telescoping lever's length. The couplers' positions were tested in two positons, aligned in the center of the draft sill or shifted to one side of the car extending the lever as far as the car would allow. Combinations of these coupler positions on both the impacting and impacted cars were tested.

Instrumentation for the test included five accelerometers in three locations, one high tension string potentiometer, and a camera system. The accelerometers and potentiometer were sampled at 5,000 Hz and filtered to 1,000 Hz. The video camera recorded at 30 frames per second and was synced with the data collection system. Figure 2 shows the instrumentation on the stationary car around the uncoupling lever. The ends of the string potentiometer are marked by circles and a connecting line to describe the measurement. Orange arrows point to the location of two of the accelerometers, which measure acceleration along the axis of the uncoupling lever.

Figure 2. Instrumentation around the Uncoupling Lever

In addition to the instrumentation in Figure 2, triaxial acceleration was measured on the top of the coupler horn. Figure 3 shows the location of the accelerometers.

Figure 3. Triaxial Acceleration Instrumentation Mounted on Stationary Coupler

Testing

A total of 18 impacts with target speeds of 4 mph or 6 mph were recorded during the testing. At each speed, three of the impacts were conducted with the couplers centered, followed by three impacts with the couplers on both cars shifted to the left of the stationary car. This position extends the uncoupling lever of the stationary car. The final three impacts at each speed were conducted with the stationary car's coupler shifted to extend the lever and the incoming car's coupler centered.

During the testing it was observed that the inserts between the three pieces of the uncoupling lever were affected by the impacts. Pieces of the lever inserts broke on the handle side of the lever. Figure 4 shows an example of the broken inserts.

Closer to the coupler end of the lever the inserts began to slide out of the designed position. Figure 5 shows the insert slipping out from its designed position between the two parts of the lever.

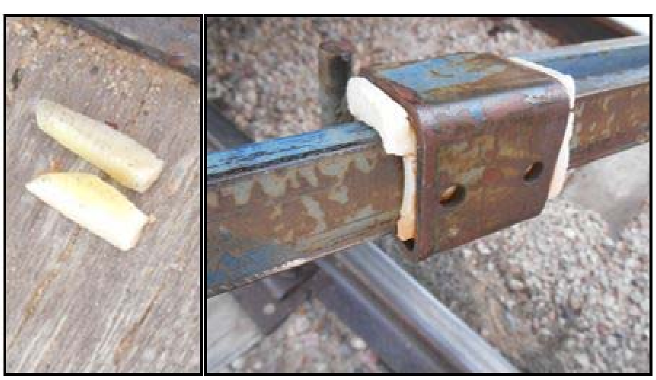

Figure 4. Broken Pieces of an Uncoupling Lever Insert

Figure 5. Insert Slipping from Designed Position

Data Analysis

Data was analyzed using a filtering process from the 1995 SAE J211-1. This recommended practice outlines the instrumentation and data processing guidelines for impact test for road vehicles. The document provides a recommended procedure based on the expected frequency response. The different responses are broken into different classes described as channel frequency classes. A 60 Hz frequency class was used to process the data from the accelerometers. That data response was then compared to the data from the string potentiometer to validate the filtered response.

Results

As one might expect, when the couplers are aligned center and center, the response of the lever is more benign. Figure 6 is a graph of the lever displacement versus time for 4 mph runs with center-center coupler alignment on top, and left-left coupler alignment on the bottom.

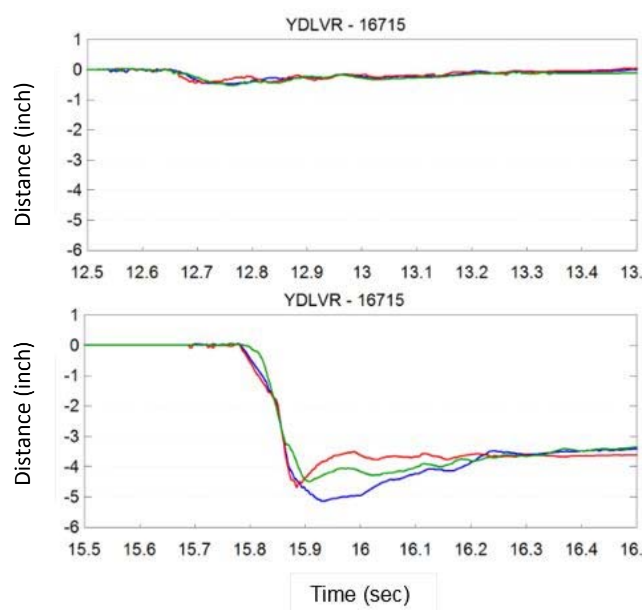

Figure 6. Lever Displacement for Center-Center and Left-Left Coupler Alignments

For the largest displacements of the uncoupling lever, the lever telescoped 5 inches in approximately 0.1 second. Though the distance is less than specified by AAR M-961, the rate of 50 inches per second is significantly higher.

Acceleration of the lever near the coupler was also more benign for the center-to-center case. Figure 7 is a graph of the lever acceleration verses time for 6 mph runs with center-center coupler alignment on top, and left-left coupler alignment on the bottom.

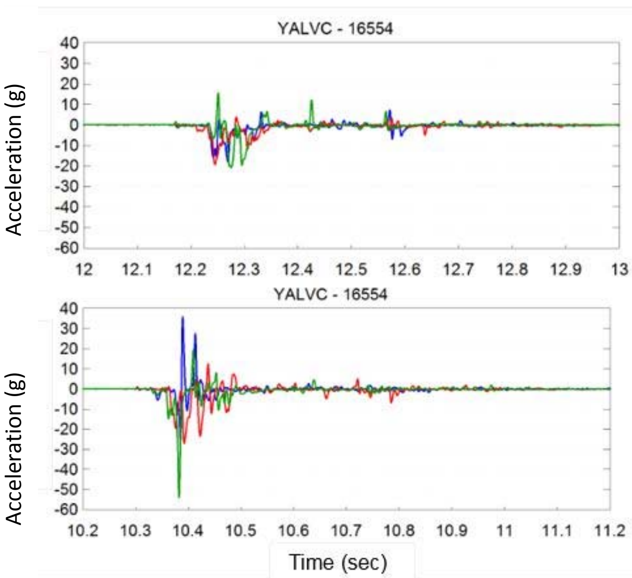

Figure 7. Lever Acceleration for Center-Center and Left-Left Coupler Alignments

Maximum lever travel occurred when the coupler was shifted to one side. For the two cars used in this test, the highest displacements were around 5 inches. Some such displacements are shown in Figure 6, the left-left alignment plot.

Though speed did not have a great effect on lever travel, speed did influence the longitudinal acceleration of the coupler. For 4 mph runs, longitudinal coupler accelerations peaked between 20 g's and 50 g's. For 6 mph runs, longitudinal coupler accelerations peaked between 40 g's and 90 g's. Examples of measured coupler longitudinal acceleration are shown in Figure 8. Both examples are center-center coupler alignments. The 4 mph run is the top plot and the 6 mph is the bottom plot.

CONCLUSION

The current specifications outlined in AAR M-961 do not reflect telescoping speed required for the uncoupling lever during an impact event. During the fatigue test in AAR M-961, the frequency for the lever is between 15 and 17 cycles per minute. If one assumes a cycle is 50 inches of travel, the telescoping rate is between 12.5 inches per second and 14.2 inches per second. Though the telescoping distance is less than specified by AAR M-961, the rate of 50 inches per second is significantly higher.

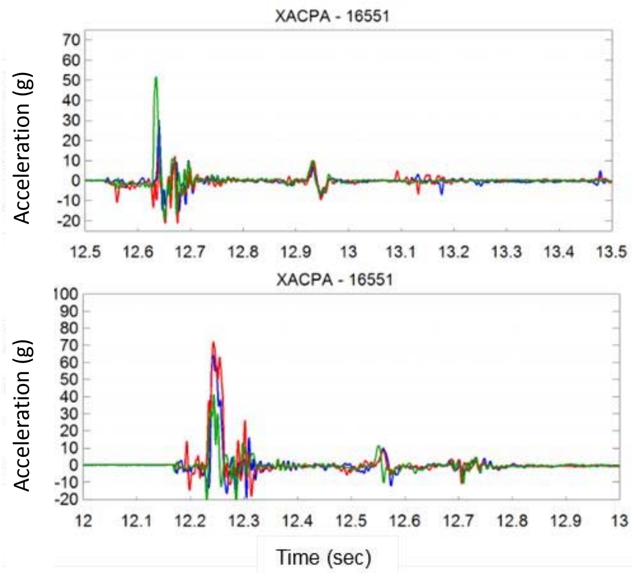

Figure 8. Coupler Longitudinal Accelerations

For this testing, coupler position had the greatest effect on telescoping distance. Especially in the conditions where the uncoupling lever is extended prior to impact.

Speed of the coupling event, between 4 mph and 6 mph, was shown to have little effect on the lever travel. Speed did have an effect on the acceleration of the coupler. For 4 mph runs, longitudinal coupler accelerations peaked between 20 g's and 50 g's. For 6 mph runs, longitudinal coupler accelerations peaked between 40 g's and 90 g's.

The AAR Coupler System and Truck Castings Committee is currently reviewing the standards for uncoupling levers. The changes that need to be made to bring this standard in line with the current demands on levers will be made by incorporating results from this test and other tests.

REFERENCES

1. Association of American Railroads. 2003. *Manual of Standards and Recommended Practices.* Section S-III. Coupler and Yoke Details, Specification M-961, "Uncoupling Devices, Special." Washington, DC.
2. Association of American Railroads. 2003. *Manual of Standards and Recommended Practices.* Section S-III. Coupler and Yoke Details, Standard S-131, "Coupler (Rotary), Type E60, Operating Rod, use with up to 6½-in. Total Draft Gear Travel." Washington, DC.
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