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Investigation of 'Fail-to-Couple' Events in Hump Yards

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Summary

In a cooperative effort between Transportation Technology Center Inc., CSX Transportation, and International Electronic Machines Corporation testing was conducted at the Transportation Technology Center to determine the root cause of failed couplings in hump yards. Results of the study show that coupler alignment and knuckle position are two critical variables that determine if two cars will couple. The testing also showed that increasing speed for the incoming vehicle does not increase the opportunity for coupling, and the potential for damage to the vehicle and coupling system components significantly increases at higher speeds.

A loaded car was placed on an inclined track and released from a stationary position and rolled toward a stationary string of loaded cars. Variations in coupler lateral alignment, knuckle position, and speed were introduced to identify the major contributors to coupling and "fail-to-couple" events. All testing was recorded using 12 high-speed cameras mounted on the wayside and on the incoming vehicle. The digital version of this *Technology Digest* includes some of the test videos.

Early test results indicate that the incoming coupler position is one of the critical factors in determining if the coupling systems successfully engage. Test results show that shifting the incoming coupler to the left (when facing the knuckle face of the incoming car) increases the probability of proper coupling. This probability, according to the small sample collected, decreases when the receiving coupler is shifted to the right

Early analysis and observations of the knuckle positions show that when the knuckle is open between 100 and 75 percent, the probability of a proper couple is only slightly affected. If the knuckle is open less than 75 percent, the probability of proper coupling drops significantly.

The influence of speed on successful coupling events is not as large of a factor as knuckle and coupler position. Although speed variations did not affect the coupling success, it did increase damage to the components. In the higher speed runs, damaged components included a cracked striker plate, two broken brake hose castings, and a cracked coupler.

Additional research with an expanded test matrix is planned for 2012. The expanded test matrix will include test runs with worn components, variations in coupler heights, and mixed loads.

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INTRODUCTION

Transportation Technology Center, Inc. (TTCI), in conjunction with CSX Transportation and International Electronic Machines Corporation (IEM), designed testing to determine the root causes for cars failing to couple in hump yards. This *Technology Digest* (TD) summarizes the approach used to study "fail-to-couple" (FTC) events and preliminary results and observations of the testing conducted at the Transportation Technology Center (TTC). Additional testing and analysis will be completed and reported in 2012. The digital format of this TD contains embedded video of some of the test runs recorded at TTC. All videos are labeled appropriately. Please click on the play button to view each of the videos.

Background

In mid-2011, CSX conducted a study to record and analyze coupling failures within the classification yard at its Selkirk Yard in New York State. The multidisciplinary team, led by the CSX Advanced Engineering group, used the study to validate FTC theories and to identify new causes of FTC events.

Over 24 hours (three, high-volume, 8-hour periods), two out of the six hump groups were observed with a series of 15 high-speed cameras. Twenty FTC events were observed and classified during the test period, excluding events where the car stopped prior to reaching the rest of the humped cars.

A review of the data from the two groups revealed that 10.5 percent of all cars experienced FTC events, and 3.3 percent of cars were stalled. Given the observations of this study, it is estimated that FTC and stall events affect a range of 7 to 23 percent of all cars humped depending upon conditions in the yard. Given the direct costs for locomotive and employee time and indirect costs associated with safety and liability, it is estimated that FTC events are a multimillion dollar issue for CSX, network-wide.

Test Overview

Testing was conducted on the Precision Test Track at the TTC. The track has a low downhill grade that is used to create impacts at a range of speeds. Four speeds (3 mph, 4 mph, 6 mph and 8 mph) were used for this test. The 3 mph speed was added to the recommended procedures for conducting impact tests of loaded freight cars, trailers, or containers found in the General Information Bulletin No. 2, Section 3.[1]

All test cars were loaded hoppers. Three of the four cars were used as the anvil string and were tied down and all brakes were set. The fourth car was used as the impact car. The receiving anvil car was equipped with a new double shelf E-type coupler, and the loaded impact car was equipped with an E-type coupler. A new coupler was chosen for the first set of tests to eliminate worn components as a potential contributor for FTC events. All testing was recorded using high-speed cameras operated by IEM Corporation.

Nine stationary cameras were used to capture each impact, including one below the couplers at the impact site. In conjunction with these nine cameras, three additional cameras were attached to the impact car using magnets. Figures 1 and 2 show the location of the stationary and car-mounted cameras, respectively.

Figure 1. Eight Stationary Wayside Cameras

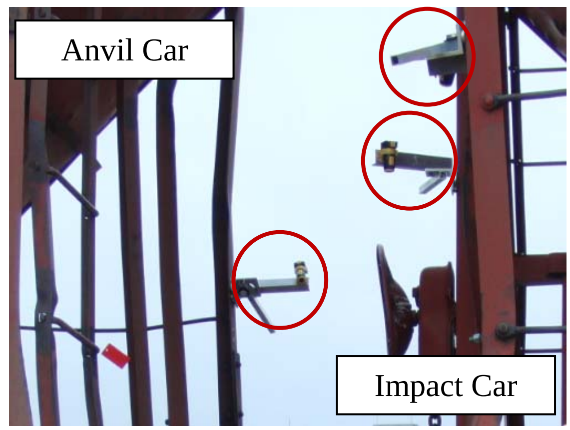


Figure 2. Three Magnet-Mounted Cameras

The following list summarizes the set of variables that were modified during testing:

- Coupler lateral position relative to the draft gear pocket
- Percent opening for incoming knuckle
- Speed

To vary the coupler position, the coupler shank was aligned with the center of the pocket then shifted to the left or right depending on the test. The total variation from extreme left to extreme right was approximately 3.5 inches. No direct position measurements were taken for any of the variables. All the positions were referenced to the observer looking at the incoming car and marked for consistency. The incoming knuckle was marked at approximate positions for 50-, 75-, and 100-percent open. The intermediate markings were based on the radial position of the coupler in the closed and 100-percent open position.

Results

The objective of the initial testing was to observe a broad range of potential FTC conditions. To address this objective, the test matrix was designed to test many conditions with a low number of repeats. As a result, the findings of this initial study only represent a small cross-section of the actual performance of coupling system components. Future tests will address the repeatability of the reported results.

Results from the testing indicate that one of the major contributors to FTC events is the incoming coupler position. Figure 3 is a summary of the results based on coupler position. The y-axis shows the number of occurrences of coupled (blue) and FTC (red) events. The x-axis indicates the test condition. The plot shows that when the incoming coupler is shifted to the right, there is a lower percentage of successful couplings. The only exception to this observation is when both incoming and receiving couplers are shifted to the right.

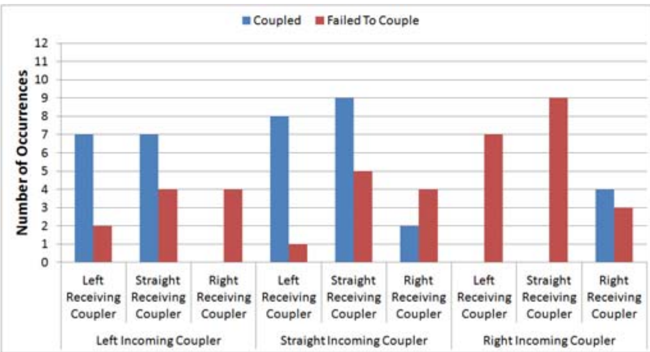


Figure 3. Test Results Based on Coupler Position

Knuckle position also proved to be a critical variable in FTC events. Figure 4 shows the test results based on the radial position of the knuckle. Results indicate that as the incoming knuckle is more open, the potential for coupling increases significantly. The plot also reinforces the observation that when the incoming coupler is shifted to the right, it is unlikely that the cars will couple correctly.

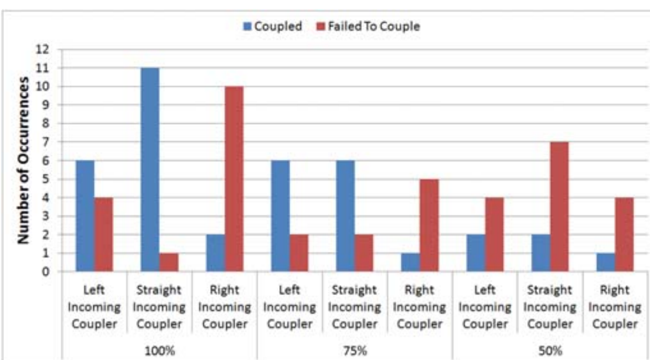


Figure 4. Testing Results Based on Incoming Knuckle and Coupler Position

Figure 5 shows the test results with respect to incoming car speed. The plot shows a large number of FTC events at lower speeds. These results are directly influenced by the type of testing conducted at the lower speeds. The majority of the slower speed tests was done with position variations of the coupler and knuckle that created increased FTC conditions (e.g., incoming coupler to the right and knuckle closed). In contrast, the higher speeds show a higher instance of coupling. Again, these results may be skewed, because most of the tests conducted at higher speeds were done with variations that were successful at lower speeds. A critical observation from the testing at various speeds is that coupling at higher speeds causes more damage to the components and vehicle. Additional testing planned for 2012 will isolate speed from coupling system positions to better determine the influence of speed on FTC events.

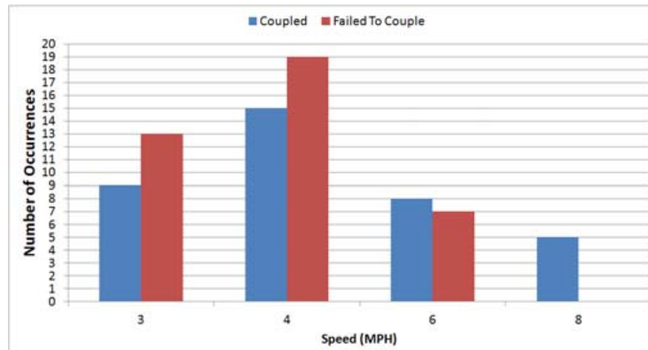
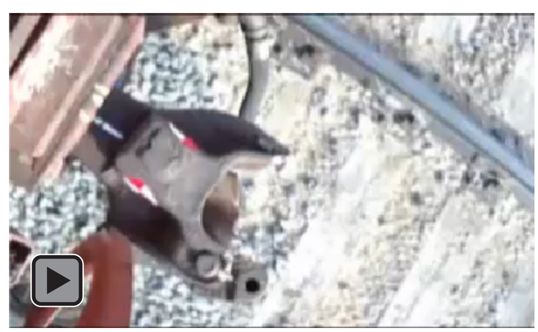


Figure 5. Testing Results based on Incoming Car Speed

COMPONENT DAMAGE

A total of five components broke during tests at speeds greater than 4 mph. The damage included cracked striker plates, broken brake hose castings, broken uncoupling levers, and a cracked coupler. Two major delays were encountered during testing. First, a draft gear was broken after repeated runs at higher speeds. The second delay was encountered during a 6 mph run with the incoming coupler shifted to the left and the receiving coupler shifted to the right. The couplers slipped past the knuckle, and both couplers made contact with the opposite car's brake hose, severing both brake hoses. Video 1 shows the test run.



Video 1. Test Run Resulting in Broken Brake Hose Castings

A coupler bypass also occurred. For this test, the incoming coupler was shifted to the right, the receiving coupler was shifted to the left, and the knuckle was 100 percent open.

At a speed of only 3mph, these two couplers made contact between the heel and front face of the knuckles. Contacting in these regions caused the two couplers to bypass and contact the opposing striker. As a result, the two cars were slightly lifted from the track, and the couplers were stuck together.

Video 2 shows the result of the test. Several attempts were made to pull the cars apart with two locomotives, but the couplers remained stuck. After the failed attempts to remove the bypass with motive power, one of the coupler heads was torch-cut from the shank to alleviate the bypass. Although statistics on bypassed couplers are unknown at this time, it is obvious that this type of event can be extremely costly in terms of train delays, component costs, and overall safety.

Video 2. Coupler Bypass Event

As a note, several planned runs were removed from the test matrix because early test results showed that testing extremes in either coupling component position or speed resulted in broken components and delays.

On the Edge of Coupling

A final observation made from the tests performed at TTC is that there is a small window that determines whether or not a particular system will couple. Videos 3 and 4 show the influence of small changes on the coupling result. The figures compare two test runs using the following conditions:

- Incoming knuckle 75 percent open
- Incoming coupler shifted to the left
- Receiving knuckle closed
- Receiving coupler straight
- 4 mph test speed

The cars shown in Video 3 successfully coupled while the cars in Video 4 did not. This scenario emphasizes that small variations in alignment can have a large influence on the ability for two cars to couple.

Video 3. Coupling Event

Video 4. Fail-To-Couple Event

CONCLUSION

Initial testing has shown that incoming coupler position and knuckle opening are key contributors to FTC events. When the incoming coupler is straight or shifted to the left (toward the knuckle face), proper coupling is more likely. Conversely, when the receiving coupler is shifted to the right (toward the knuckle face) proper coupling is less likely.

For knuckles, test results indicate that if the knuckle is open between 75 and 100 percent, proper coupling is affected very little. If the knuckle is open less than 75 percent, the proper coupling drops significantly.

Speed variation was not as large of a factor for proper coupling as knuckle and coupler position. The most important observation related to speed for this testing is that as speed increases, the potential for critical component damage increases. Additional research to isolate speed as a variable is necessary to determine an optimum coupling speed.

Acknowledgements

Special thanks to Kim Bowling and Don Lauro from CSX as well as Chad Koehnen and Brent Frey from IEM for their participation in the testing at TTC.

References

1. Damage Prevention and Freight Claim Committee. February 2000. “General Information Bulletin No. 2 Rules and Procedures for Testing of New Loading and Bracing Methods or Materials.” RAILINC, Cary, NC.