TECHNOLOGY DIGEST
TD-13-015
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Comprehensive Report of Fail-to-Couple Testing

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Summary

Transportation Technology Center, Inc. investigated the mechanisms that cause fail-to-couple (FTC) events. Tests were conducted on speed, coupler position, and knuckle position to gather data for statistical analysis. Information from this analysis could be used to alter the operating practices of individual hump yards to reduce the total number of FTC events.

Analysis of the data showed:

- If the relative position between the couplers is larger than a specified amount, the chances of a FTC are statistically higher.
- An incoming coupler operating against the knuckle side of the draft sill results in a FTC more often than in other positions when the receiving knuckle is closed.
- A FTC event is statistically more likely when the incoming knuckle is open 50 percent.
- A FTC event is statistically less likely when the receiving knuckle is open 100 percent.
- A FTC event is not affected by coupling at 3, 4, or 6 mph.

Additional testing may bring about greater resolution on the intermediate points of some of the variables.

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INTRODUCTION

Transportation Technology Center, Inc. investigated the mechanisms that cause fail-to-couple (FTC) events. This digest includes the history, analysis, and conclusions of the three tests conducted during the project.

The first test was performed to better understand the mechanisms that cause FTC events. Building on an investigation done previously by CSX Transportation and International Electronic Machines Corporation, the first test focused on speed, lateral coupler position, and knuckle position. Four speeds, three coupler positions for both cars, three knuckle positions for the incoming car, and one knuckle position for the receiving car were tested.[1]

Because the first test indicated that speed was not the main cause of FTC events, the second test was conducted at only two speeds. Because coupler position was a dominant factor in the first test, two positions were added on coupler alignment for each car for greater resolution. This resulted in five total possible positions for each car. Knuckle position for the incoming car varied between two knuckle positions. To further explore the effect of knuckle position on FTC events, two knuckle positions were added to the receiving car resulting in three total possible positions for this car.

The primary goal of the third test was to evaluate the configurations that had been deferred for later testing. Three test speeds were planned. The knuckle positions for the incoming car remained at two and the receiving car with three possible positions. This resulted in five total possible coupler positions for each car.

A total of 248 runs were conducted. After testing was completed, a statistical analysis was done on the data collected at a 95-percent confidence level. The following sections summarize that information.

TEST SETUP

Testing was conducted on the Precision Test Track at Transportation Technology Center, Pueblo, Colorado. The track has a low downhill grade that is used to create impacts at a range of speeds.

All test cars were loaded hoppers. Three of the four cars were used as the anvil string. 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. At the start of the testing, a new coupler was chosen to eliminate worn components as a potential contributor for FTC events.

All testing was recorded using high-speed cameras. 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.

TEST FACTORS

Speed

The investigation involved four speeds at 3, 4, 6, and 8 mph. Speed was tested to see how it affected the frequency of FTC events.

When speed was analyzed with every data point included from all three tests, there was a statistical difference in the likelihood to couple. However, the main reason for the significance of speed was due to five runs, all conducted at 8 mph. When excluding the 8 mph runs, the total number of runs was reduced to 243. A logistic regression on the 243 runs returned a p-value of 0.125, showing no statistical significance. As a result, the runs will be analyzed without speed as a factor, and the 8 mph tests will be excluded from further analysis.

Test personnel observed that FTC at various speeds resulted in some occurrences of bypassed or broken components. Figure 1 shows one such component. Any further study examining the likelihood to couple versus speed should consider the risk of bypass or broken components. An ideal speed range could be determined to maximize coupling while minimizing bypass or broken components.

Figure 1: Cracked Guard Arm of Coupler

Coupler Position

During the investigation, five positions were identified and marked on the draft sill. These marks served as a visual aid to assist the research when aligning the coupler for each of the five positions. The coupler was shifted to one side as far as possible and marked. Then, the coupler was shifted to the opposite side as far as possible and marked. After the center was marked, the distance between the left and center was marked as left/center. The same was done for the right/center.

This was done for both couplers. All left and right markings were designated by left or right side when looking at the locomotive for both couplers.

With the remaining 243 runs, after removing the 8 mph runs, a statistical analysis was done on the coupler positions of each car without considering the position of the coupler on the other car and also with the combined effect of both coupler positions. The most statistically significant factor was the interaction of the couplers.

The absolute difference between the coupler positions is statistically significant in predicting FTC events. This absolute difference was calculated by taking the five positions mentioned and assigning a number from left to right; i.e., the farthest left position equals 1, the center equals 3, and the farthest right position equals 5. In this case, position 5 is the right side of the train for both couplers.

For clarification, interactive illustrations are presented in Figures 2 and 3. Taking the absolute value of the difference between the number assigned for the incoming car's coupler (ICP) position and the receiving car's coupler (RCP) position; i.e., where the ICP number is 3 and the RCP is 5, the resulting absolute coupler difference is 2. All position combinations can be seen by clicking on the interactive link on Figure 4.

The absolute coupler difference shows approximately 40 percent of the variation observed and is the largest factor of the coupling mechanism.

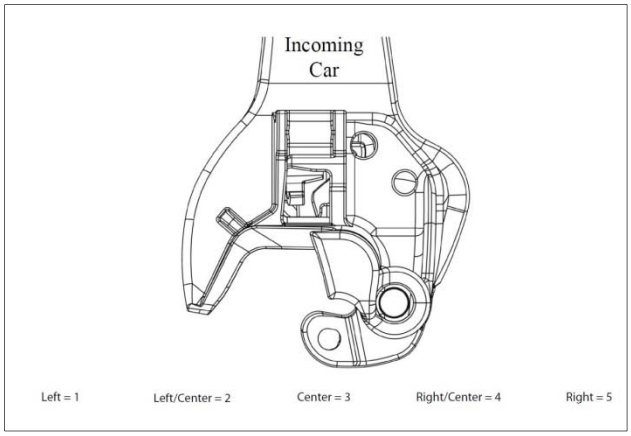

Figure 2: Link to Interactive Incoming Coupler Alignment

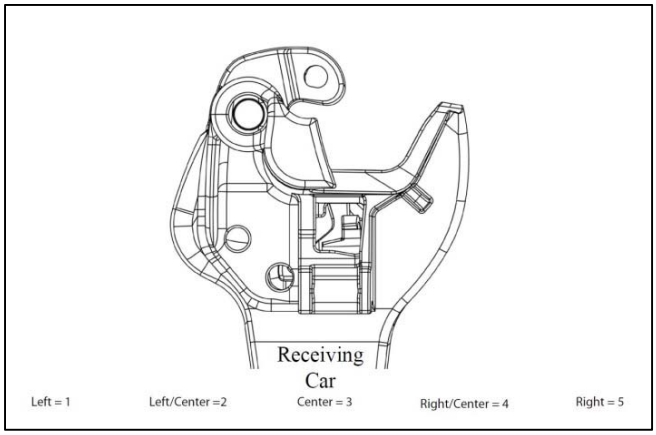

Figure 3: Link to Interactive Receiving Coupler Alignment

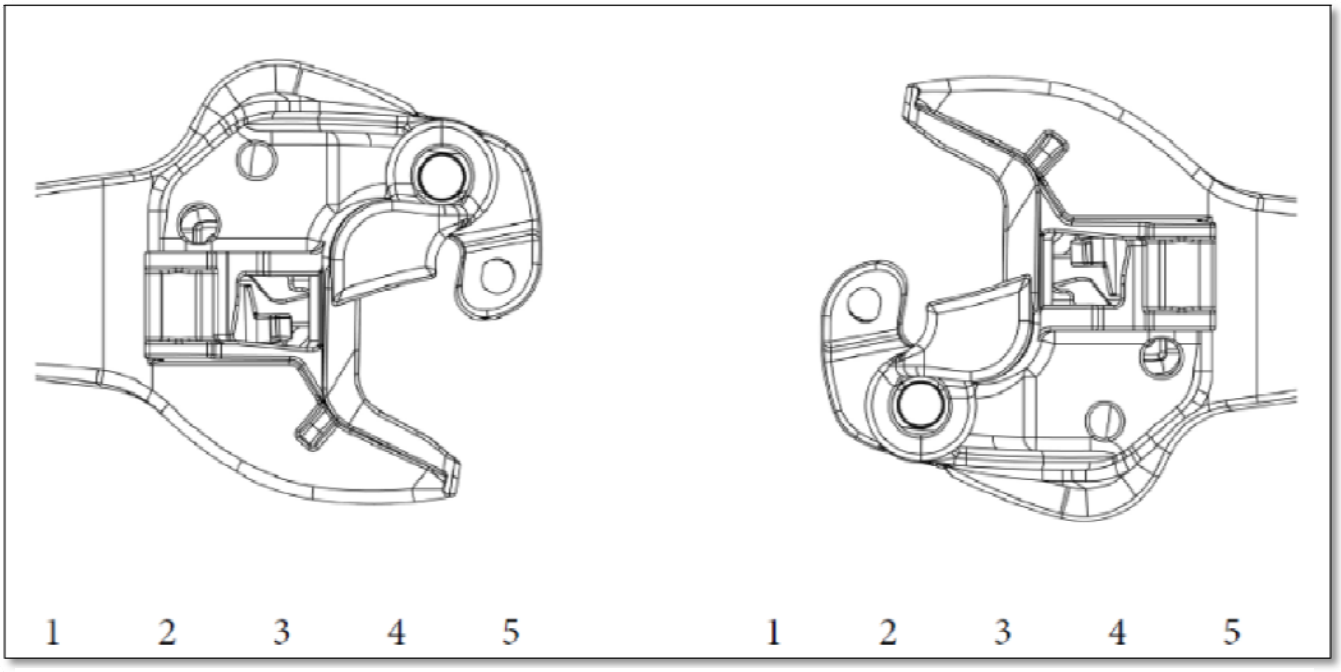

Figure 4: Link to Absolute Coupler Difference Interactive Tool

To further examine how each coupler difference had an effect, a general linear model of knuckles and couplers and their interactions was followed up by a binomial analysis. The binomial analysis showed the three following separations:

- Absolute coupler differences of 0 or 1 have a lower probability of a FTC than absolute coupler differences greater than or equal to 2.
- An absolute coupler difference of 2 is more likely to result in a FTC than differences of 0 or 1 but less likely than differences of 3 or 4.
- Absolute coupler differences of 3 or 4 have a higher probability of FTC than absolute coupler differences less than or equal to 2.

Coupler positions were also analyzed individually. Using a binary analysis showed position 5 was statistically more likely to result in a FTC than other positions when the receiving knuckle was closed. In all other knuckle positions, it performed similar to other coupler positions.

The summary of the analysis on the couplers found two main points

- Two or more positions variation between the couplers indicated a statistically higher probability of a FTC.
- An incoming coupler in position 5 resulted in a FTC more often than other positions when the receiving knuckle was closed.

Knuckle Position

The significance of knuckle positions to FTC events is best explained by their individual position rather than relative position to each other and is identified using a general linear model of knuckles and couplers individually and paired.

The analysis indicated that when the receiving knuckle is closed and the incoming knuckle is open 50 percent, a FTC is more likely to result than when the receiving knuckle is closed and the incoming knuckle is open at 75 or 100 percent. In revenue service, the convention is to have the receiving knuckle closed, thus limited data was collected with the receiving knuckle in other positions for further analysis.

The receiving knuckle showed a statistical difference when open 100 percent. The chances of the result of a FTC occurring are statistically less likely when the receiving knuckle is 100 percent open. The data did not show a statistical difference between closed and 75 percent open.

However, it should be noted that when the receiving knuckle was open 75 percent, the incoming knuckle was open 100 percent. This probably had an effect on the analysis of the receiving knuckle open 75 percent.

Like the coupler analysis, the knuckle analysis showed two major conclusions.

- When the receiving knuckle was closed and the incoming knuckle was open 50 percent, a FTC event was statistically more likely to occur than when the receiving knuckle was closed and the incoming knuckle was open 75 or 100 percent.
- When the receiving knuckle was open 100 percent, a FTC event was statistically less likely.

CONCLUSION

Statistical analysis presented here identifies factors concerning speed, coupler position, and knuckle position.

Analysis of the data showed:

- Two or more position variations between the couplers indicate a statistically higher probability of a FTC.
- With the receiving knuckle in the closed position and the incoming coupler in position 5, it is likely to result in a FTC more often than with incoming coupler is in other positions.
- A FTC event is statistically more likely when the incoming knuckle is open 50 percent.
- A FTC event is statistically less likely when the receiving knuckle is open 100 percent.
- A FTC event is not affected by coupling at 3, 4, or 6 mph.

Additional testing may bring about greater resolution on the intermediate points of some of the variables.

Using this analysis, alterations could be made to the operating practices of individual hump yards to reduce the total number of FTC events.

REFERENCE

1. Sammon, Devin, Kari Gonzales, and Jake Hunter. July 2012. “Investigation of ‘Fail-to-Couple’ Events in Hump Yards.” *Technology Digest* TD-12-014, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.