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Study of Force Required to Separate Pressurized Air Hoses

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Summary

Testing conducted by Transportation Technology Center, Inc. (TTCI) on pressurized air hoses showed that compared to standard gaskets, wider glad-hand gaskets increase the force by over 60 percent of the original value required to separate pressurized air hoses on railcars. The results of this study have the potential benefit of reducing undesired emergency brake applications, particularly on cars with cushion draft gears that rely on the hose separation force being higher than the force required to move the end-hose trolley.

Testing was conducted in three phases, all using the same cars. Phase 1 testing confirmed that a used air hose had reached steady-state behavior and could be used as a control hose in other phases. Phase 2 testing validated that unused air hose/gasket assemblies of the same make and style chosen at random are statistically the same, and Phase 3 testing measured the effects of different hose/gasket assembly designs on the separation force.

TTCI continues to collect paired end hoses that have been involved in revenue air hose separation events to investigate the role that they may play on undesired emergency brake applications

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INTRODUCTION

Railway manufacturers have designed new hoses and produced wider glad-hand gaskets to help eliminate the unintentional occurrences of separated air hoses on railcars. Glad-hand gaskets with larger contacting surfaces were developed to reduce the incidence of radial misalignment in air hose couplings.[1] Such misalignment can result in separation forces of less than 100 pounds, thereby increasing the chances for an undesired air hose separation on cars with certain types of end arrangements.[2] In addition to reducing the chance of radial misalignment, glad-hand gaskets with larger contacting surfaces also increase the force required to uncouple the pressurized hoses. Based on published results, some of the newly designed equipment can increase this force by 100 percent.[2]

To quantify the effects of the new equipment, TTCI conducted testing using railroad cars and attached air piping to compare the hose separation forces associated with different styles of hose/gasket assemblies. These tests were conducted on hose assembles coupled in a normal manner and not at the extremes of fitment described in Reference 1.

Test Design

Testing was conducted in three phases, all using the same cars. Phase 1 testing confirmed that a used air hose had reached steady-state behavior and could be used as a control hose in other phases. Phase 2 testing validated that unused air hose/gasket assemblies of the same make and style chosen at random are statistically the same, and Phase 3 testing measured the effects of different hose/gasket assembly designs on the separation force.

Testing was conducted inside a building located at Transportation Technology Center (TTC) in Pueblo, Colorado, using standard rotary dump gondola cars equipped with 33-inch-long straight-shank hoses. Testing indoors created a stable temperature. A railcar mover was used to pull the decoupling car away from the stationary car, which had the hand brake fully applied. Both cars were equipped with standard draft gear rather than end-car cushioning devices. Air was provided through the brake pipe system on one car. The hoses were laced and the gasket alignment checked by an experienced carman.

The solid trainline on these cars terminates with an end cock rather than an angle cock. This allows for a linear force path as the air hoses are stretched taut during the hose separation. The end cocks of these cars are located on the right-hand side of the car, and the hoses are joined next to the couplers rather than passing underneath the couplers.

Instrumentation for collecting data during testing included a pressure transducer scaled from 0 psi to 100 psi and a 5,000 lbf load cell scaled from 0 lbf to 1,200 lbf. Data from the separation was collected at 1,000 samples per second through a data acquisition system to determine the peak force during the separation. Ambient air temperature was also recorded using a thermometer with a digital display. Figure 1 shows the pressure transducer and load cell installed on the stationary car between the end cock and the end hose.

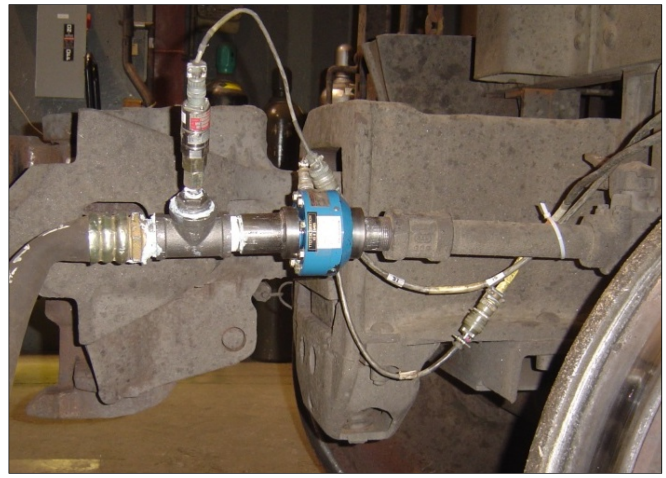

Figure 1. Data Collection Instrumentation

Phase 1

Two well-worn, noncondemnable hoses removed from revenue service cars were provided by a Class I railroad and tested at TTC to determine if they could be used as control hoses for all phases of testing. TTCI researchers conducted a visual inspection of the glad hands and concluded that the hoses had been involved in more than 50 separation events. Each test was conducted with unused gaskets in the used hoses. TTCI researchers looked for trends after a number of separations.

Several statistical tests were used to confirm that the pull apart forces of the hoses were not trending and had reached stability. The first statistical test used was a run chart in Minitab to check for randomness. The next step was to split the data into two groups. A mood median test indicated no difference between the two groups.

Based on the nine data points collected during the testing, there was no trending on the well-worn hoses. Median separation force was 471 lbf. Therefore, either hose could be used as the control hose for Phase 2. Therefore, the first hose, well-worn hose 1, was chosen as the control hose for further testing.

Phase 2

Phase 2 of the testing was designed to verify that three hose/gasket assemblies of the same make and style chosen at random are statistically the same in terms of separation force. This test was also designed to find differences between three distinct hose/gasket assemblies, two of which were standard hoses with standard gaskets manufactured by different companies, referred to here as Assembly A and Assembly B, and one style with a slightly different glad hand and a wider gasket referred to as Assembly C. Similar to Phase 1 testing, this test contained nine runs. The gaskets in each hose were changed before each separation. To keep from ordering the hoses and confounding the data, the hose types were alternated between the three assemblies.

All of the separation forces for hoses in Assembly A fit a normal distribution with equal variance. A one-way analysis of variance (ANOVA) indicated with 95-percent confidence there was no statistical difference detectable between the three hose/gasket combinations in Assembly A.

Assembly B hoses were checked using the same statistical tests for distribution and variance. The separation forces of Assembly B were normally distributed but had different amounts of variance. The Kruskal-Wallis test, used in place of ANOVA, indicated no statistical difference between the three Assembly B hose/gasket combinations.

Assembly C, a newer style hose with a wider gasket, was the final assembly analyzed in Phase 2. The one-way ANOVA indicated with 95-percent confidence there was no statistical difference detectable between the three hose/gasket combinations in Assembly C.

Table 1 shows the median values for all of the hose assemblies. The values in this table show that the separation force for hoses that used standard gaskets (A and B) were similar and significantly lower separation forces compared to the hose that had a wider gasket style (C).

Table 1. Median Separation Force

Hose	Median (lbf)
Assembly A	479.8
Assembly B	472.7
Assembly C	705.9

Phase 3

Phase 3 matched the hoses and gaskets of different styles together and tested the performance of end hose/gasket assemblies after several separations. Each hose and gasket was unused at the start of the test, and gaskets were not replaced prior to each separation. An unused gasket gives a higher separation force than a used gasket for the first few separation events, then quickly reaches a steady state range of separation forces. A total of 30 separations per assembly were conducted to ensure confidence of the steady state behavior.

Testing followed the matrix shown in Table 2. Four individual hoses and gaskets of three different types (A, C, or D) were used in the testing for a total of 12 individual hoses and gaskets paired up in 6 different combinations. The subscript numbers in Table 2 indicate different hoses of the same style used on each car for the tests.

Assembly A was a standard style hose and gasket and is the same combination used in Phase 2. Assembly B from Phase 2 was not retested in Phase 3 because the results were expected to be nearly redundant to Assembly A, as based on the results from Phase 2. Assembly C is the hose/gasket combination used in Phase 2. Assembly D was added for Phase 3 testing. This assembly uses a standard style end hose paired with a wider style gasket.

The first statistical analysis was completed for the distribution and variance of each combination. Assembly C combination paired with Assembly D was not normally distributed. All other combinations were normally distributed. The analysis showed that the combinations did not have equal variance.

Because of the type of variation and distributions of this data, two methods were used to analyze the data. First, a visual inspection of the data was conducted followed by a series of mood median tests. The visual inspection of the data was done using the box plot in Figure 2 and the values of each quartile in Table 3.

Table 2. Run Matrix

Decoupling Car Hose/Gasket	Stationary Car Hose/Gasket
Assembly C_1	Assembly C_2
Assembly C_3	Assembly D_1
Assembly C_4	Assembly A_1
Assembly D_2	Assembly D_3
Assembly D_4	Assembly A_2
Assembly A_3	Assembly A_4

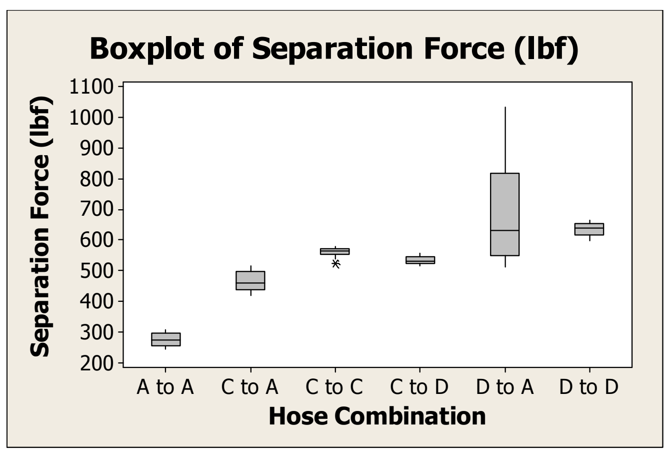

Figure 2. Box Plot of Separation Force by Hose Combination

Table 3. Hose Combination Quartile

Hose Combination	Quartile 1	Median	Quartile 3
A to A	256.39	272.58	297.31
C to A	438.90	458.62	496.00
C to C	554.29	562.82	571.65
C to D	523.38	532.21	546.34
D to A	547.80	632.30	818.90
D to D	616.99	639.36	653.49

There is a noticeable separation force increase between any hose/gasket combination compared to the "A to A" combination (standard end hoses and gaskets). This difference shows that the wider hose and gaskets (C and D) perform better regardless of the hose/ gasket combination with which it is mated.

To compare a specific hose/gasket combination, a box plot of all combinations matched with Assembly A is ideal. Figure 3 shows there are distinctions between all three combinations. Though Assembly D has more variation, it also has a higher separation force.

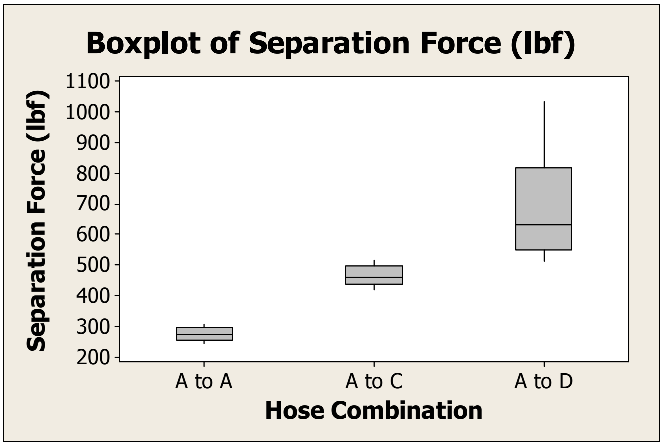

Figure 3. Box Plot of Separation Force for Combinations involving Assembly A Hose and Gasket

CONCLUSION

Testing conducted by TTCI showed that compared to standard gaskets, wider glad-hand gaskets increase the force required to separate pressurized air hoses. This has the potential benefit of reducing undesired emergency brake applications, particularly on cars with cushion draft gear that rely on the hose separation force being higher than the force required to move the end hose trolley.

When equipped with unused standard gaskets, the median pull apart force of used and unused hoses are similar — between 450 lbf and 500 lbf.

When examining wider gasket types, pull apart forces were higher. When comparing hoses with unused gaskets (separations of Assembly C), the median pull apart force was over 700 lbf. When comparing hoses and gaskets over several separation events, wider gasket styles had higher median separation forces than the standard style hoses and gasket. A standard style hose/gasket assembly matched to a standard style hose/gasket assembly had a median separation force of 272 lbf after reaching steady state. All other combinations involving at least one hose/gasket assembly with a wider style gasket had a median separation force greater than 450 lbf.

FUTURE WORK

TTCI is collecting more paired end hoses that have been involved in revenue air hose separation events for investigating the role that end hoses may play on undesired emergency brake applications.

REFERENCES

1. Tournay, H. and B. Madrill. November 2008. "Factors Influencing Hose Separation Forces." *Technology Digest*, TD-08-049, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.
2. Jimenez, E. et al. October 2009. "Root Cause of Undesired Hose Separations and a Solution." ASME 2009 Rail Transportation Division Fall Conference. RTDF2009-18024. Ft Worth, Texas.