TECHNOLOGY DIGEST

TD-15-016

©JUNE 2015

TIMELY TECHNOLOGY TRANSFER

The work described in this document was performed by Transportation Technology Center, Inc.,
a wholly owned subsidiary of the Association of American Railroads.

Testing to Correlate Gasket Stiffness and Separation Force

Devin Sammon and Gerald Anderson

Summary

As part of the Association of American Railroads' Strategic Research Initiatives Program, Transportation Technology Center, Inc. conducted compression and separation tests to compare and correlate end hose gasket stiffness to the force required to separate two pressurized hoses.

Previous testing conducted in 2013 showed that the nonstandard gasket designs increased the separation force of two end hoses.[1] To better understand if these changes were related to new materials or a shape change, compression testing was conducted using a gasket fixture and two gasket types. Based on the compression testing results, separation tests were repeated for the two gasket types in an attempt to understand the higher forces of the newer gasket designs.

In general, clear correlations were not evident between the compression testing of the gaskets and the separation forces. This testing showed that there should be no assumptions of any linear behavior when compressing gaskets.

The test conducted during this study showed that the nonstandard gasket designs had higher measured stiffnesses during the compression testing and the separation force was significantly higher.

Please contact **Devin Sammon (719) 584-0702** with questions or concerns regarding this *Technology Digest.* E-mail: Devin_Sammon@ttci.aar.com.

INTRODUCTION AND BACKGROUND

As part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program, Transportation Technology Center, Inc. (TTCI) conducted two tests to compare and correlate end hose gasket stiffness to the force required to separate two pressurized hoses.

Gaskets are used throughout the train to ensure an air-tight seal between components. End hose gaskets are used to maintain the connection from car to car. To decrease the likelihood of air hose separations, manufacturers have provided the industry with designs meant to increase the force required to pull pressurized hoses apart.

TTCI testing in 2013 showed that the newer gasket designs did increase the separation force.[1] The results of testing to determine the effects of the gasket material on the separation force are reported here.

Gasket Compression Test Procedures

The compression test was designed to provide information about the stiffness of the gasket material. Instead of simulating real world application and pressing two gaskets together, only one gasket was tested at a time. This was done to avoid confounding individual gasket stiffness and stiffness of the pair. Three compressions of the gaskets were conducted per gasket sample.

The testing jig for the compression testing was a modified version of the lower portion of the permanent set fixture from M-602 of the *Manual of Standards and Recommended Practices*.[2] TTCI test personnel added a pressure tap to the jig so the pressures in a train line could be mimicked during the compression testing. To mimic the shape of the glad hand, a thin steel plate was cut to maintain the shape of the gasket protruding from the base of the jig. Figure 1 shows the pieces of this jig.

Figure 1. Test Jig with Gasket Disassembled

Twenty-five gaskets of each type were tested. Each gasket was placed in the testing fixture and placed on top of a load cell in the loading machine (Figure 2). A thin, smooth plate was placed on top of the gasket to reduce the chance of leaks. A preload was placed on the gasket of approximately 200 lbf to seal the gasket for pressurization. The fixture was then pressurized to approximately 90 psi and checked for leaks. The gasket was then compressed until a force of 700 lbf was reached or the gasket was compressed to the steel plate. The load was released and the air pressure from tap was released. The vertical gasket deflection was measured using a linear variable differential transformer (LVDT).

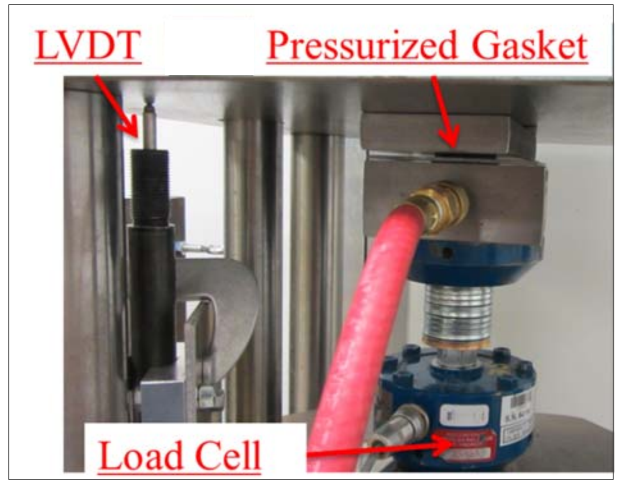

Figure 2. In situ Gasket Test

Gasket Compression Test Results

During the design of this test, test engineers believed that the compression range would remain in a near linear range of stiffness. However, when analyzing the results of the compression test, this assumption did not always hold true. As a result, two methods were used to analyze the compression data. The first method attempted to linearize the stiffness by taking the force required to compress the gasket and dividing by the distance the gasket had been compressed. The second method approximated the slope of the force with respect to distance while the vertical load was being released.

Figure 3 shows an example of the first method. The figure shows the force in kips (thousand pounds) on the upper plot and the distance in inches on the lower plot, with time on the x-axis for both. This particular test required a force of 229 lbf to compress the gasket 0.039 inch. The calculated stiffness would be about 5,871 lbf/in.

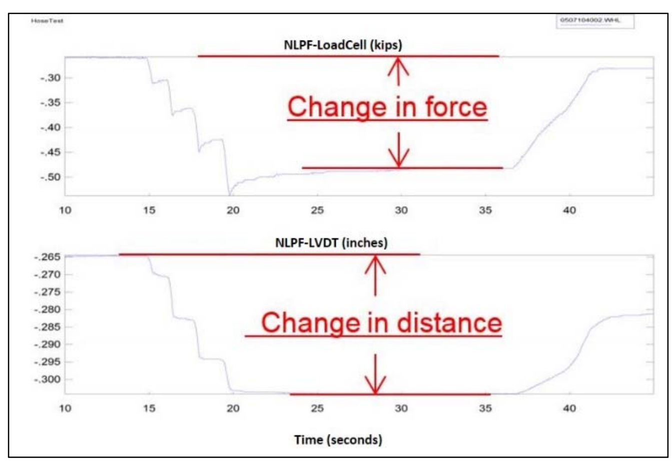

Figure 3. Method 1 of the Stiffness Calculation

Method 2 required plotting the vertical load on the y-axis and the distance compressed on the x-axis. Over the period of the release, a line was fit to the data. The stiffness of the gasket was then calculated using the slope of that line. Figure 4 shows an example of the release. In this case, the stiffness was about 2,380 lbf/in.

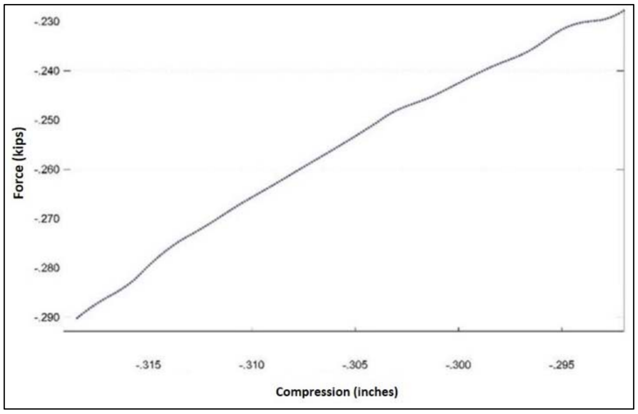

Figure 4. Plot of Vertical Force vs. Distance

As shown, there were differences in the results of the stiffness depending on the method used. Using both methods, the calculated stiffness of the gaskets was highly variable. After evaluating the possible variability of each method and external influence of each method, the first method was used to select the gaskets for the separation testing.

Separation Test Procedures

Based on the results from the gasket compression testing, six pairs of gaskets were chosen for each design type to use in the separation tests. Table 1 shows the compression test results. Based on the results shown, a stiffness rank was assigned.

Table 1 shows that the compression results for standard gasket styles, the stiffness of which varied 30 to 40 percent for the stiffest to least stiff gasket pair selected for the separation testing.

Table 2 shows the same results for the nonstandard gasket pairs chosen for separation testing. The results show that the compression results for the nonstandard gasket style, the stiffness of which varied 30 to 50 percent for the stiffest to least stiff gasket pairs selected. Comparing Table 1 and Table 2 shows that the nonstandard gasket pairs were at least 1000 lb/in stiffer than the standard pairs. This result was expected based on the previous separation tests[1] and the difference in gasket cross-sectional area.

Table 1. Standard Gasket Pairs — Compression Results

Stiffness Rank for the Gasket Pair	**Force/Deflection Result** (lbf/in)
1	6,300–6,500
2	5,600–5,700
3	5,300–5,400
4	4,900–5,000
5	4,600–4,600
6	4,500–4,500

Table 2. Nonstandard Gasket Pairs — Compression Results

Stiffness Rank for the Gasket Pair	**Force/Deflection Result** (lbf/in)
1	10,500–11,000
2	9,900–10,100
3	9,000–9,200
4	8,200–9,000
5	7,700–8,100
6	7,300–7,600

The separation tests were performed using two cars and a locomotive similar to testing done in 2013.[1] Figure 5 shows the test setup.

Figure 5. Separation Test Setup

Unused glad hands and end hoses were used in this testing. The end hoses were replaced at the beginning of the testing of each gasket type. The end hose pair was used for the duration of the testing for that type of gasket. The cars used were rotary dump coal gondolas with straight end hose arrangements, as Figure 5 shows. Also shown is the load cell and pressure transducer used to collect separation forces and brake pipe pressure.

The brake pipe was charged to 90 psig, the same pressure as used in the gasket stiffness test. The air in the train line of the first car was bottled, then the locomotive and first car pulled away to separate the hoses. Every effort was made to pull away at a slow but constant speed.

A total of 40 separations were made with each gasket pair. The first 10 separations were considered as initial tests to achieve steady state behavior and get consistent separation forces, based on past test experience. The data used in the analysis was based on the final 30 separations.

Separation Test Data and Discussion

Table 3 shows the median value for the maximum separation forces and pressures at separation of the last 30 separations of the six gasket pairs tested. The table also presents the stiffness rank (1=highest stiffness) based on the compression testing.

Table 3. Standard Gasket Test Results

Standard Gasket Set No.	Median Force at Separation (lb)	Pressure at Separation (psig)	Separation Force Rank	Stiffness Rank
1	293	89.1	6	6
2	329	90.3	5	5
3	395	90.8	1	1
4	336	89.8	4	3
5	359	89.7	3	2
6	371	90.4	2	4

There is some correlation of the maximum force data to the stiffness rank for the standard gasket type. The highest force was the stiffest in compression testing, and the lowest force was the least stiff gasket. The same can also be said for correlation to the pressure at the time of separation. The pressure was slightly lower for set No. 1 and was adjusted upwards in subsequent tests by increasing the feed valve setting to achieve a minimum of 90 psig.

The force variation between sets for the standard gasket type was between 25–35 percent, whereas pressure levels varied by only 1.5–2.0 percent.

Table 4 shows the median value for the maximum separation forces and pressures at separation of the last 30 separations of the six gasket pairs tested. Table 4 also presents the stiffness rank (1=highest) based on the compression testing.

Table 4. Nonstandard Gasket Test Results

Non Standard Gasket Set No.	Median Force at Separation (lb)	Pressure at Separation (psig)	Separation Force Rank	Stiffness Rank
1	793	92.1	3	1
2	757	92.4	4	5
3	709	91.3	6	3
4	840	92.0	1	2
5	805	91.7	2	4
6	743	91.0	5	6

There appears to be little correlation between force or pressure versus stiffness for the nonstandard gasket set.

With a generally wide disparity in force levels between sets (15–20%), there is little that can be deduced in separation forces based on gasket stiffness results from the compression test. Pressure levels were held fairly constant throughout the testing (1.5%).

An interesting note is that on two occasions during the nonstandard gasket testing, one of the gaskets dislodged from the glad hand at separation and was recovered 20 to 30 feet away.

CONCLUSION

Based on test results, researchers are only able to draw some high level conclusions from this test. Like the testing in 2013,[1] this test shows that the newer gasket styles increase the separation forces.

It is clear that future testing with end hose gaskets should not assume any type of linear behavior during a compression test. The high variability of the material may have become more consistent after several loading cycles as the material strained repeatedly. This theory could not be confirmed with the available data.

FUTURE WORK

Currently, no future work is planned specifically for gasket evaluation. Future work will focus on other components and their effect on separation force.

REFERENCES

1. Sammon, Devin, et al. July 2013. "Study of Force Required to Separate Pressurized Air Hoses." *Technology Digest* TD-13-019. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.

2. Association of American Railroads. 2002. *Manual of Standards and Recommended Practices*. Standard M-602, "Gaskets, Air Hose," in Section E—Brakes and Brake Equipment. Washington, DC.