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# Factors Influencing Hose Separation Forces

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**Summary**

Radial misalignment of air hose couplings can reduce the hose separation force. Limited testing by Transportation Technology Center, Inc. shows that separation force can be reduced from 450 pounds to 50 pounds.[1]

A root cause of the reduced force appears to be that the resulting contact area between the gaskets is reduced. This reduces the stiffness of the gaskets and the force they generate to react to the radial locating lips on the coupling.

A possible remedy is to increase the outside diameter of the gasket to accommodate the radial misalignment.

This investigation was initiated as a result of an investigation into unwanted air hose separations (UAHS) and in-service failures due to air brake malfunctions.

UAHS are responsible for in-service delays estimated to cost North American railroads $3.1 million annually.[2] Much work has been done to reduce these separations, including measures to control air hose heights in service and different design initiatives. UAHS do, however, remain a problem.

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## INTRODUCTION

Railroads are experiencing service reliability problems that are partly caused by the in-service failure of brake systems. TTCI was tasked by the Association of American Railroads under their Strategic Research Initiatives Program to investigate the root causes for in-service failures attributed to the brake system and to recommend solutions.

A Pareto analysis of in-service failures identified hose separations as the second most prevalent failure mode (31 percent of all failures) behind that associated with valve failures (39 percent of failures).[2] During an investigation into possible root causes of these separations, TTCI found that the longitudinal separation force could be varied by a factor of approximately 10, depending on the manner in which the hose couplings were engaged in the coupling operation.[1]

This *Technology Digest* discusses the possible factors influencing the air hose separation forces and possible solutions.

## FINDINGS

In an effort to determine the causes for air hose separations, separation data was analyzed, and tests and workshops were conducted.[1] During a workshop at Strato Inc., the Air Hose Separation Technical Advisory Group observed tests developed by Strato to establish the hose separation force.

Two air hoses were assembled in the test rig, and the assembly was pressurized, simulating brake pipe pressure. The assembly was then pulled apart in a manner described more fully in reference 3, except the hose straps were not introduced to the assembly, and the full separation force passed through the hose couplings.

The force required to separate the hoses varied between 450 and 50 pounds.[1] The magnitude of the separation force was dependent in the way the operator connected the hose end couplings. To understand the role that the connection process plays in determining the separation force, the different functions of the hose couplings need to be understood:

- The primary function of the air hose coupling is to provide a leak-free air connection of the main brake pipe between cars, cars and the locomotive, or cars and the end-of-train device in the train. This is done by:
  - Aligning the two gaskets (Figure 1) of the connecting couplings concentrically. Gasket concentricity is obtained by locating the couplings radially with respect to the gaskets against arc-shaped engaging faces on the lugs of the couplings (Figures 1 and 2).
  - Providing sufficient preload on the gaskets so the train pipe pressure does not force them apart or produce leaks. Preload is provided by engaging the lugs axially with respect to the gaskets (Figure 3).
- A secondary function of the air hose coupling is to allow separation when a longitudinal load is applied to the hoses, as is the case when cars are separated from one another. For this function, radial locating lips are provided on the lugs. In order to separate the hoses, these lips have to override one another (Figure 4).

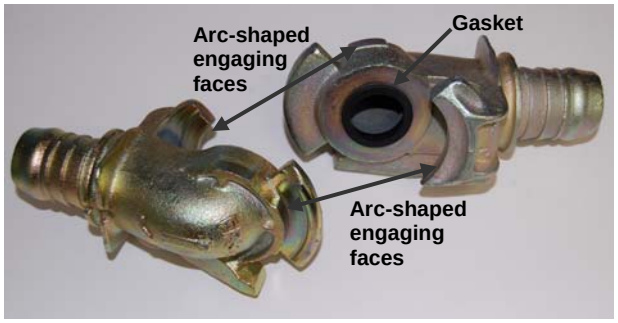


**Figure 1**

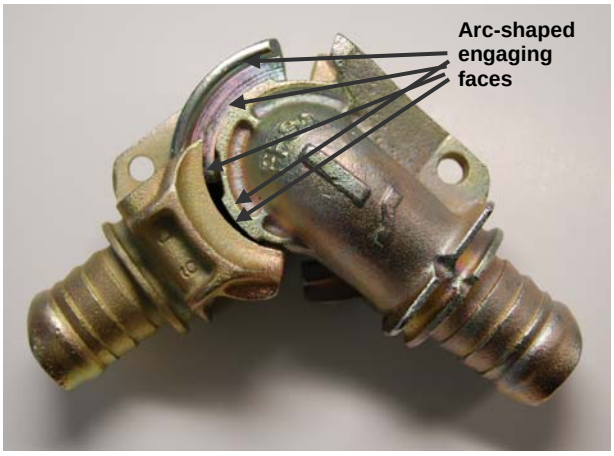


**Figure 2**

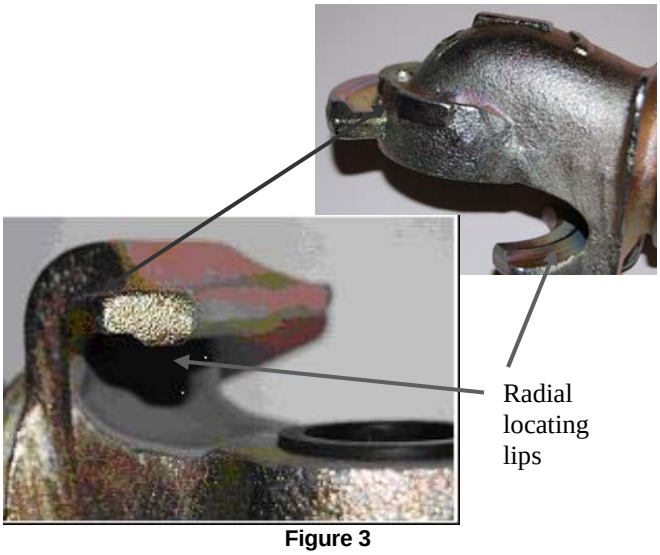


**Figure 3**

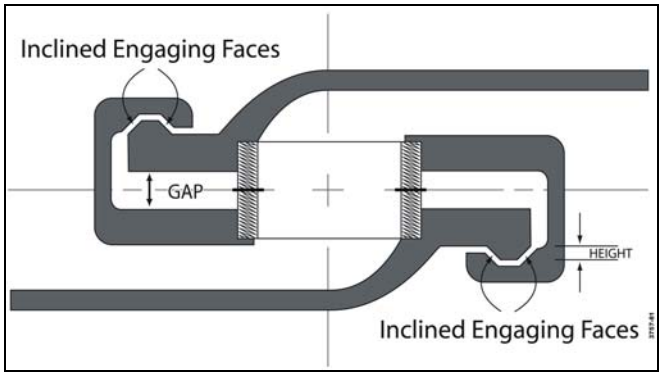


**Figure 4. Disengagement of Radial Locating Lips**

The inclined faces of the radial locating lips provide a wedging action, forcing the hose couplings together, and compressing the two coupling gaskets until the locating lips override. Obviously, the gap between the couplings must be greater than the height of the lips.

The force required to override is a function of the:

- Angles of the inclined engaging faces
- Coefficient of friction
- Degree of precompression of the gaskets
- Height of the radial locating lips
- Stiffness of the gaskets, which, in turn, is a function of:
  - The bulk modulus of the gasket material
  - The contacting area between the gaskets

During and after the test, test engineers observed that the accuracy of the couplings was high. The same couplings were used in every comparative test conducted, first at Strato and then at The Transportation Technology Center, Pueblo, Colorado. The question is, where did the variability lie in conducting the separation test when the same, accurate components were used in every comparative test conducted?

Test engineers observed that if care was not taken when initially engaging the couplings (i.e., to force them to a radial position) a nonradial location could be induced (Figure 5) or even forced. Consequently, the gaskets engaged in a nonradial manner (Figure 6), appreciably reducing the contact area between them, and, presumably, the effective stiffness of the gasket combination, and, apparently, the separation force.

Interestingly, if radial misalignment was observed in two coupled couplings, they could be forced into a seemingly radial position against the arc-shaped engaging faces; however, all that occurred was that the gaskets sheared relative to the coupling housings, and retained the original common contact area. Consequently, any attempt to rectify misalignment without uncoupling and recoupling the couplings does not increase the hose separation force.

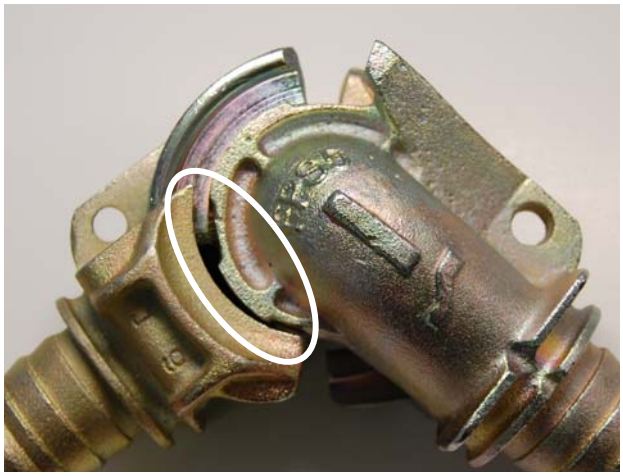

**Figure 5. Nonradial Location between Couplings**

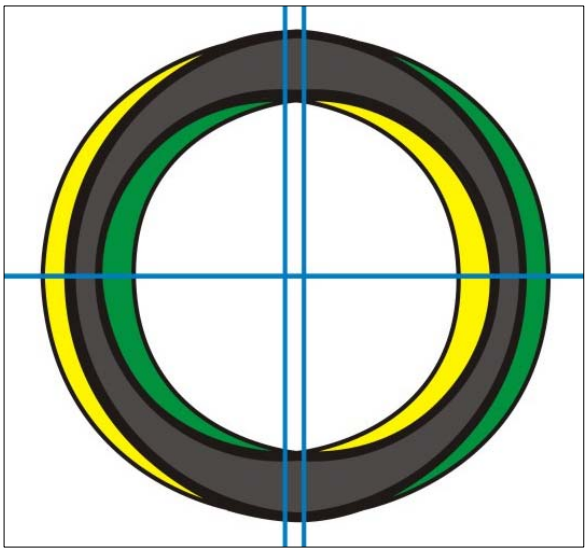

**Figure 6. Effective Contact Area between Gaskets**

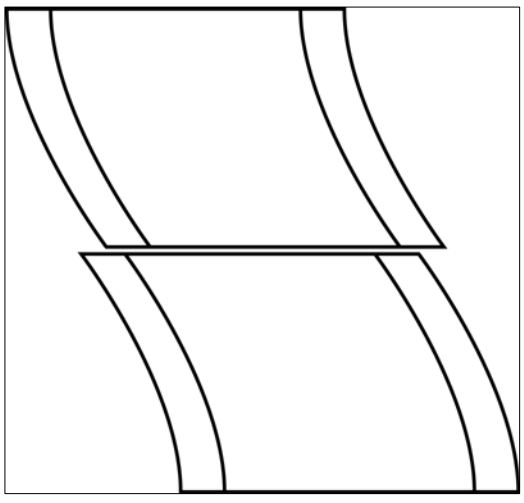

**Figure 7. Shear Deformation of Gasket**

An extreme form of radial misalignment occurs when the couplings are coupled with the radial locating lips riding on top of one another. This takes some force, but not an unreasonably high force when the leverage of the pipes on the coupling is considered.

No further tests have been conducted; however, findings presented here do lead to some interesting questions:

- All tests were made with new couplings and gaskets. What is the minimum separation force with worn couplings and worn and degraded gaskets?
- What is the influence of nonradial coupling on in-service leaks?

## POSSIBLE SOLUTIONS

Possible solutions to reduce hose separation forces have been considered. The hose coupling and the coupler are the components with the most required interchangeability; i.e., improvement may be limited to changing the geometry of the couplings. It would seem, however, that modifications could be made to the gasket without major interchangeability issues; i.e., an increase in the outside diameter of the gasket by ¼ inch would assist in increasing the intergasket contact area, but it would require an inventory of two gaskets. It would allow connecting between two couplings with different gasket outer diameters. The hose separation force would be increased under these conditions, because the contact area should be greater for a set radial misalignment than if two similar couplings of smaller diameter were joined. An increase in gasket outer diameter may increase the effort required to couple two hoses, but modifying the modulus of elasticity of the gasket material may reduce this effect.

However, general awareness of the condition may help mitigate the situation. A useful training tool can be created by attaching one hose to a bench and then coupling it to another hose in a correct or radially misaligned manner. The hose connected in a misaligned mode can easily be pulled apart by hand (obviously, when not charged to train pipe pressure).

## CONCLUSIONS

Hose separation forces are reduced when there is radial misalignment of the couplings when connecting hoses. A root cause of the reduced force appears to be that the resulting contact area between the gaskets is reduced. This reduces the stiffness of the gaskets and the force they generate to react to the radial locating lips on the coupling.

Tests should be conducted to determine if separation forces and/or resulting leaks are increased with worn couplings and worn and degraded gaskets.

It is recommended that the AAR Brake Systems Committee task the supply industry to investigate the effectiveness and practicality of increasing the outer diameter of the air hose coupling gasket.

## Acknowledgements

TTCI thanks Strato Inc., and in particular, Michael Foxx for his enthusiastic support of the air hose separation initiative and for pointing out the possibility of a reduced separation force when hoses are placed in tension.

TTCI also acknowledges the participation of Consolequip, BNSF Railway, CN Railway, and UP in this initiative.

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