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Possible Root Causes of Unwanted Air Hose Separations

Harry M. Tournay, Benjamin Madrill

Summary

Possible root causes for unwanted air hose separations (UAHS) are suggested together with design strategies to avoid these separations.

Functional requirements for air hose assemblies are presented for consideration by the Association of American Railroads' (AAR) Brake Systems Committee.

Further tests are suggested to verify whether or not hose contact can occur at grade crossings that induce vertical hose separation.

Two separation modes, vertical and longitudinal, are defined and discussed together with their causes and means to avoid them.

UAHS are responsible for in-service delays estimated to cost North American railroads \$3.1 million annually.¹ Much work has been done to reduce the incidence of these separations including measures to control air hose heights in service as well as a number of different design initiatives. UAHS do, however, remain a problem.

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INTRODUCTION

Railroads are experiencing capacity constraints on high tonnage lines that are exacerbated by the in-service failure of brake systems. Transportation Technology Center Inc. (TTCI) was tasked by the AAR, under their SRI Program to investigate the root causes for in-service failure attributed to the brake system and to recommend solutions for consideration by the AAR Brake Systems Committee (BSC).

A Pareto analysis revealed that 39 percent of failures are attributable to problems associated with air brake valves, 31 percent of failures are attributable to hose separations, and 11 percent each attributable to brake rigging and air leaks.¹ Air brake valve failures are currently being investigated and will be reported separately. An initial investigation into factors influencing air hose separations suggests there may be many causes for separations and lists them.²

Two coupled car pairs, known to have been involved in air hose separation incidents, have been brought to the Transportation Technology Center (TTC) located near Pueblo, Colorado, for tests in an attempt to replicate these incidences. These tests have proved unsuccessful:

- One car in the first car pair brought to TTC showed trolley damage and had a damaged hose replaced
- The second car pair brought to TTC was involved in a hose separation that may have been associated with train action, as Figure 1 shows:

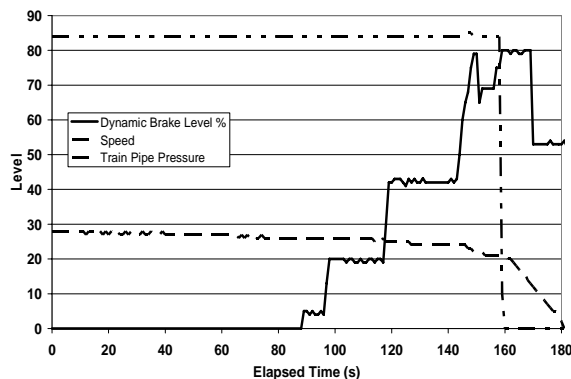


Figure 1. Hose Separation Prior Events

A steadily increasing dynamic brake load was reduced from 80 percent to 65 percent and then ramped-back to 80 percent. As this latter action took place, the train pipe pressure dropped to zero as the hoses separated. Multiple tests at TTC to simulate this action and cause a separation were unsuccessful.

Further separation data has been obtained from the railroads for analysis and it is anticipated that these results will be presented in a future *Technology Digest* (TD).

At this stage testing was stopped to approach the problem differently and to concentrate on the physics of the possible modes of separation of two hoses.

PHYSICS OF SEPARATING TWO COUPLED AIR HOSES

The air hoses, when charged with air can either be:

- i. Vertically separated; i.e., lifted to a height where the hose couplings have rotated sufficiently with respect to one another that the engaging lugs on the hose couplings release (Figure 2).

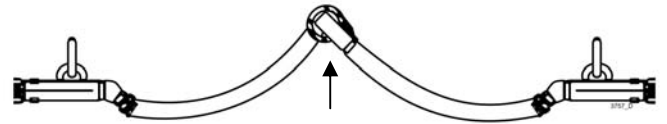


Figure 2. Vertical Separation

This is a motion almost opposite to what the carman would do when coupling an air hose. Rough measurements suggest that the static vertical load required to lift and rotate the hose couplings is of the order of 50 pounds.

- ii. Longitudinally separated; i.e., as in a normal car cut motion (Figure 3).

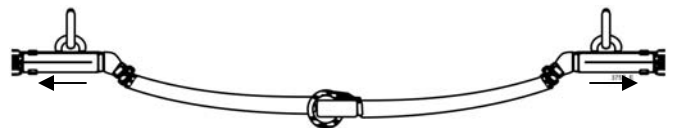


Figure 3. Longitudinal Separation

The shut-off cocks are moved apart and tension applied to the air hoses until the hose couplings separate. The force to separate the hose couplings is normally 450 pounds; however, as illustrated at the Strato test facility, NJ, this force can be reduced to less than 50 pounds for new hose couplings and hose coupling gaskets.

It is presumed that this force can be reduced further depending on:

- The original mode of coupling the hose couplings
- The condition of the hose coupling gaskets and hose coupling engaging lugs

This issue is discussed in a separate TD.²

No other separation mode appears other than physically destroying one or both hoses.

POSSIBLE ROOT CAUSES FOR AIR HOSE SEPARATIONS

Given the above two uncoupling modes, the root causes for air hose separations can be explored with respect to each mode.

Vertical Separation

Vertical separation according to Figure 2 requires:

- A vertical force
- Space above the hoses to move to a position that allows the hose couplings to rotate sufficiently to uncouple

It is suggested that the vertical force can only come from the hose assembly contacting some object between the tracks.

Obvious objects of contact are already known and recorded by the railroads (e.g., supermarket trolleys, animals struck by the train). For these objects, preventative action is obvious, even if difficult to avoid.

Highway grade crossings are possible objects of contact. Given the length of overhang of the cars that are typically involved in air hose separations (Figure 4 shows dimensions for a typical tri-level autorack car) and maximum vertical spring travel of 3 ¾ inches, a correctly set hose height at 4 inches above rail level could, under solid spring conditions, reduce to:

$$4 \text{ inches} - [(47/2)/(33/2)] \times 3.5 = -0.98 \text{ inches} \dots\dots\dots (1)$$

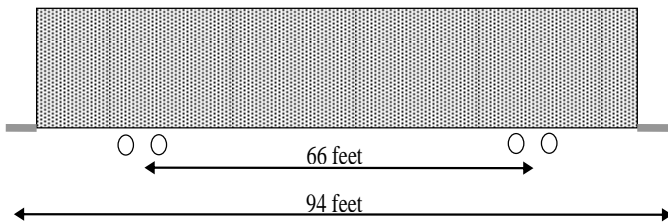


Figure 4. Typical Tri-Level Autorack Car Dimensions

It may be argued that it is unrealistic to assume that the car body would pitch to the degree that the truck springs would compress at one end of the car by 3 ½ inches and extend the same amount at the other end. However, grade crossings are notorious for their change in track stiffness, low spots resulting from differential settlement, and drainage issues. It is highly possible that:

- There may be vertical depression of about ½ inch in the track some 14 feet before the crossing
- The edge of the crossing may lie ½ inch above rail level

In this scenario, if the hose assembly moves down only 3 inches, it will strike the edge of the crossing. This would imply a vertical spring deflection of:

$$3 \times [(33/2)/(47/2)] = ¾ \text{ inch} \dots\dots\dots(2)$$

This order of spring deflection is highly possible in an autorack car running at speed, if not probable, although it must be argued that a degree of interference between hose and crossing is required to produce a vertical impact load.

Examination of many hose couplings suggests multiple contacts (Figure 5) although it is argued that this occurs prior to hose height adjustments or when hose straps are broken.

To verify whether contact is being made with grade crossings, some type of tape may be placed on the underside of an autorack car and then examined after the train traverses a route known for hose separations. Observable marks would suggest contact. TTCI is encouraging this test on two railroads.



Figure 5. Hose Coupling showing Multiple Contacts

Contact with a grade crossing is, however, not a sole condition for a vertical hose separation; there has to be “space” to move up into for the hose. Normally, the underside of the coupler obstructs this motion.

Observation of a TTX test, which did result in a separation, shows that the hose moved out from underneath the coupler before separating in the vertical mode, as Figure 6 shows.

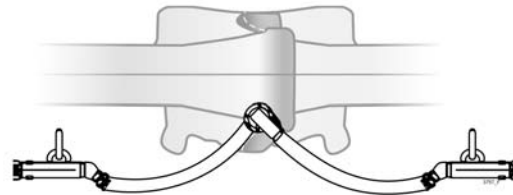


Figure 6. Vertical Mode Separation

This motion can only occur if the end cocks are given sufficient relative lateral and/or angular motion to move out from under the “plan view” of the coupler. The lateral bending stiffness of the coupled hose assembly prevents the hose couplings from moving if the end cocks are constrained.

Consequently, vertical hose separation may be avoided by one or a combination of:

- Maintaining a good vertical track profile at grade crossings (difficult). Limits need to be set as to what “good” implies.
- Maintaining crossings so that they remain below rail level (causes problems for automobiles)
- Developing end hose assemblies that restrict lateral and rotational motion of the end cock relative to the car (although negotiating certain curves obviously results in relative lateral motion between body and coupler). The latter caveat is addressed if the hose assembly follows the lateral and swing motion of the coupler, and thus keeps the hose assembly under the plan profile of the coupler.

Longitudinal Separation

Longitudinal separation can only occur if the end cocks of the coupled hoses move longitudinally apart relative to one another. This can only occur if:

- There is relative longitudinal motion between the end cock and the coupling center on at least one coupler

- There is resistance to this motion, through friction and/or longitudinal hose dynamics, to induce forces that exceed the hose coupling separation force in any end hose assemblies that permit longitudinal motion
- There is longitudinal dynamics in a coupled end hose assembly in which the end cocks do not move relative to one another (this is considered unlikely)

To prevent longitudinal separation:

- Ensure that there is no longitudinal motion between the end cock and the coupling center by using an end hose assembly that follows the coupler
- Or ensure free motion in any end assemblies that permit relative longitudinal motion between the end cock and the coupling center line, with these requirements:
 - Induced forces that do not exceed the hose coupling separation force in any end hose assemblies by ensuring undamaged/well repaired and structurally strong end assemblies that do not bind
 - Ensure that the hose coupling separation force is high enough by ensuring that:
 - Hose coupling gaskets are new and undamaged
 - Hose couplings are not damaged or worn
 - Possibly improving the design of hose couplings²

DISCUSSION AND CONCLUSION

Possible root causes for air hose separations are proposed with suggested solutions. None of the causes have been replicated, because air hose separations are a systems issue and it is difficult to introduce all variables simultaneously.

Tests are proposed, however, to verify whether contact is being made between grade crossings and hose couplings. Results will assist in verifying the possibility that vertical hose motion can still be the cause of vertical separations, notwithstanding recent work done to reduce this mode through limiting hose heights.

The work described in this TD leads to the possibility of generating the following functional requirements to evaluate designs and for consideration by the BSC:

1. End assemblies shall provide minimal (preferably zero) lateral or rotational motion to the end cock/hose nipple so that the hose couplings of coupled end hoses cannot move out from under the plan profile of the coupler without elastic bending or torsion of the end hoses.
- End hose assemblies must induce a maximum of 30 pounds of resistance to longitudinal motion, resulting in tension between coupled hoses, and at

any part of the end cock stroke, of end equipment having a longitudinal degree of freedom.

3. The positioning, orientation, and free play of end cock/end hose nipple (in order that the hose coupling of the hose assembly will not drop below rail level with hose strap removed) or an end hose assembly must be used that is strong enough to withstand the force of a hose breaking as a consequence of being caught in a switch; i.e., this implies no permanent deformation under these loads with the end equipment under any longitudinal stroke position.
4. A vertical load of 1,000 pounds applied vertically upwards or downwards to any portion of the end of car equipment shall not result in permanent deformation; i.e., to ensure a robust design.
5. End of car equipment shall not be functionally damaged during a coupler bypass; i.e., to avoid damage.
6. A “correct” relationship relating the longitudinal position of the hose nipple, the hose length, and the hose strap adjustment height; i.e., to assist in avoiding dragging hoses or hoses that are “forced” into kinked positions.

Future Work

TTCI will be conducting further tests to establish whether vertical track perturbations at grade crossings contribute to vertical impacts.

Further reports are anticipated on:

- The role of air hose coupling condition on pull-apart forces
- A functional specification based on findings 1 to 6 above

A final TD will summarize the established root causes for air hose separations.

Acknowledgements

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REFERENCES

1. Tournay, H. M. et al., (in review) “Pareto Analysis of the Causes for In-service Brake Failures.” *Technology Digest*, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colo.
2. Tournay, H. M. and Benjamin Madrill. (in review) “Factors Influencing Hose Separation Forces.” *Technology Digest*, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colo.

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