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Factors Influencing Unwanted Air Hose Separations

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Summary

As part of the Association of American Railroads' Strategic Research Initiatives Program, Transportation Technology Center, Inc. (TTCI) investigated the root causes for unwanted in-service hose separations.

Information and data identifying factors that influence unwanted air hose separations (UAHS) is presented together with interim conclusions, which suggest:

- UAHS are mainly associated with long cars having long travel drawgear, although other vehicle types of cars are subject to UAHS.
- UAHS seem to be a function of:
  - Site-specific issues, possibly track features/condition/grade crossing condition
  - Car-specific issues including:
    - Component condition
    - Possible manufacture/fitting/setup
    - Design
- A minority of UAHS are due to the train striking objects on the track; e.g., animals.
- Tests of specifically identified bad actor cars at TTCI have not yet revealed a root cause.
- A more fundamental approach may have to be taken.

A way forward in the process of identifying root causes for UAHS is recommended, including specific analyses, tests, and investigations.

UAHS are responsible for in-service delays estimated to cost North American railroads $5.4-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 that are exacerbated by the in-service failure of brake systems. Transportation Technology Center Inc. (TTCI) was tasked by the Association of American Railroads (AAR), under their Strategic Research Initiatives (SRI) Program to investigate the root causes for unwanted in-service hose separations and to recommend solutions.

As a first step to identifying root causes, the six major railroads were approached for statistics on their in-service failures. These statistics were then compared and a Pareto analysis[1] developed for the industry as a whole and revealed the following:

- 39 percent of failures are attributable to problems associated with air brake valves
- 31 percent of failures are attributable to hose separations
- 11 percent each are attributable to brake rigging and air leaks.

This digest reports on an investigation into the possible causes for hose separations. It:

- References data on hose separation failures obtained from both railroads and car operators
- References initial tests conducted and a workshop held by TTCI
- Suggests further tests, analyses, and investigations to establish the root causes for air hose separations.

Analysis of Data on Air Hose Separations

Air hose separation data for a period of 1 year was obtained from a major North American railroad. This data related to a total of 1,877 hose separations during the year considered. These hose separations were reduced from 5,000 hose separations some 5 years previously, the reduction mainly being attributed to improved hose height adjustments.

The data comprised:

- City and state (station) at which the hose separation occurred; this provided information on track features within 5 miles either side of the station but no precise location of the hose separation event
- Train symbol and date time
- Delay time
- Comment on the cause for the hose separation or failure (all were associated with air hose separations)
- The identity of the two cars involved; sometimes only one or no car identity was given

The causes given for the failures were not always clear. In approximately 87 percent of the reports, either the comment alluded to a hose separation, or the comment was sufficiently vague so as not to define that it was not due to a separation.

In approximately 13 percent of the reports, a more definite cause was given:

- In 2 percent of cases, hose separation occurred between two of the locomotives
- In 2.8 percent of the cases, hose separation occurred between the end car and the end-of-train (EOT) device. Since the train size was, on average, 82.5 cars, there are (discounting locomotives), on average, 83.5 couplings (including the EOT). Consequently, all else being equal, the incidence of failure should be 1 / 83.5 = 1.2 percent. The last car to EOT separations are 2.3 times this number (2.8 percent) suggesting issues with this coupling.
- In 7 percent of cases, the report was definitive regarding the cause of failure. This was segregated as follows:
  - Known poor condition of equipment/components (6 percent). Example: air hose condition (hose, gasket, coupling), air hose bracket condition, uncoupling lever fouling.
  - Train struck crossing or obstacles on the crossing
  - Train struck obstacles on the track (e.g., animals, shopping carts)
  - Dragging air hoses (worn through in the process)

Interestingly, when objects were struck on the track, the resulting separation was as far back in the train as the 28th car.

The data was further analyzed without removing any of the above data from the dataset.

Figure 1 shows the incidence of failure as a function of position in the train.

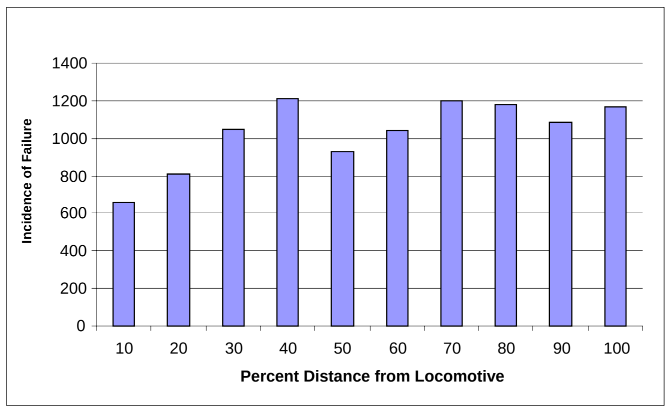

Figure 1. Distribution of Failures within the Train

Interestingly, the incidence of separation in the first 20 percent of the train length from the locomotive are 70 percent of those in the rest of the train.

The failure data was then related to car type and location on the track. The following was found :

- A car ≥ 70 feet long has 8 times greater chance of a hose separation than cars < 70 feet long
- Cars with drawgear stroke ≥10 inches account for 86 percent of all separations

- 45 percent of separations occurred on track where there is a combination of:
  - Posted speed >45 mph
  - Curvature <1 degree
  - Grade <1 percent

  Since, on western railroads, the incidence of curvature <1 degree (tangent track) is approximately 74 percent, and since speeds and grades are closely associated with curvature, it may be concluded that separations are 45/74 = 0.6, or 60 percent less prevalent on tangent track.
- Only 8 percent of separations occur on track where:
  - The posted speed is <35 mph
  - Curvature generally >3 degree
  - Grade >1 percent

  Since, on western railroads, the incidence of curvature ≥3 degree is approximately 6 percent, and since speeds and grades are closely associated with curvature, it may be concluded that separations are 8/6 = 1.33, or 33 percent more prevalent on curved track.

Figure 2 presents the data relating to the location of hose separation incidents according to station. The stations are arranged in Pareto form and identified by a number representing the order of the station in terms of the Pareto analysis. Incidents were reported at 913 stations with a maximum number of 12 separations occurring at one particular station.

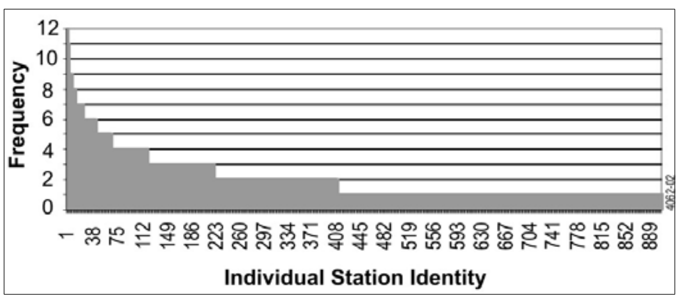

Figure 2. Frequency of Air Hose Separations Registered at Stations for 1 Year

The data indicates that there may be times where the separation incident is entered twice in the database. Consequently, all stations, at which three or more separations have occurred in a year, have been examined. The total number of these stations is 225 and account for 963 of the total of 1,876 incidents in a year (51 percent). This suggests that, of all incidents, some 50 percent *may* be site-specific.

On the other hand, the other 50 percent *may* either be site specific, random, or car-specific.

The railroad supplying this data has also developed a map of its network indicating incident sites that suggests certain routes and locations at or on which a large number of the incidents occur. This would confirm the site-specific conclusions.

Other Available Information

Other information has been gleaned from either the railroads or car owners. It does not necessarily relate to the dataset analyzed above.

- One railroad noted that automotive trains accounted for more than 25 percent of all hose separations (Figure 3) with three particular train types predominating.
- Car designs with >20-inch travel cushioning units accounted for 82 percent of the variance
- Cars with >20-inch travel cushioning units, coupled to like cars in one particular train, accounted for 81 percent of that train's separations
- Data collected regarding train speed when the hose separation occurred is shown in Figure 4. This data is not standardized with respect to the average speed profile of trains but may indicate that separations predominate at speeds above 30 mph.

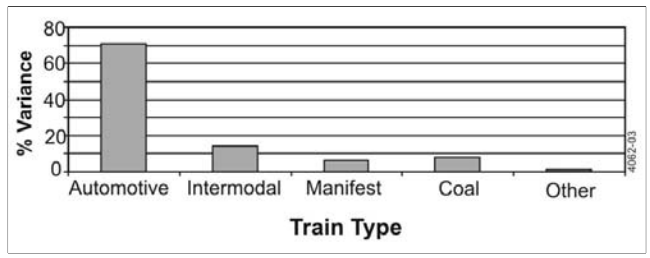

Figure 3. Variance of Separations per Train Type

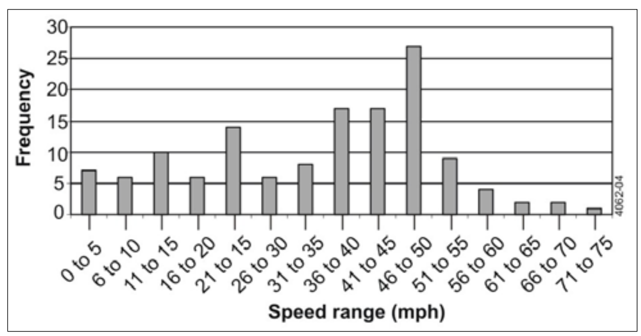

Figure 4. Frequency of Hose Separations vs. Speed

- Longitudinal train action is obviously a further possible factor. Interestingly:
  - 65 percent of hose separations occurred with the locomotives in dynamic brake mode; the remaining 35 percent being equally divided between idle and throttle positions T1 to T8.
  - 59 percent of hose separations occurred on downgrades; 49 percent occurred on downgrades between 0 and 20 ft/mile and 10 percent on downgrades between 20 and 40 ft/mile. 30 percent occurred on upgrades between 0 and 20 ft/mile.

- A car owner has analyzed the performance of different types of hose controls used on long cars with long travel drawgear compared with the conventional design. There are three basic designs:
  - Standard arrangement, fixing the hose to the end of the car, used for all "short" car types with short travel drawgear.
  - "Trolleys" that permit longitudinal motion of the end of the hose that is attached to the carbody. Trolleys also provide a degree of lateral and vertical, linear, and angular motion.
  - Designs for the purpose of this TD will be called "moveable brackets," which are attached to the coupler yoke and move longitudinally with the coupler. These devices restrict the relative motion of the hose relative to the coupler but allow degrees of lateral motion depending on the precise design.

Table 1 shows the relative performance of these design types and suggests that, when standardized according to fleet size, there is little difference between performances of all nonstandard types of brackets. Care must be taken with this table, however, as fleet size may not represent car usage.

Table 1. Bracket Performance

Bracket Type	Number of Separa-tions	Percent All Separa-tions	Fleet Size	Percent Separations/ Fleet Size
Standard	105	4.3	48,581	0.22
Trolleys	1698	70	77,740	2.18
Moveable Brackets	600	25	27,262	2.20

Tests

Limited tests have been conducted at TTC in the past few months on four cars known to be associated with separations. These tests have proved unsuccessful in establishing a root cause for failure.

Tests conducted in the past by TTX have indicated that hose end contact made with grade crossings may cause separations.

Interim Conclusions

Care must be taken in drawing conclusions at this stage of the investigation. However, certain conclusions must be drawn in order to proceed with further investigations. For example, it appears:

1. Hose separations do account for the majority of in-service delays traditionally associated with the term hose separations and are mainly associated with long cars with long-travel drawgear.
2. Separations do, however, occur between shorter cars, locomotives, the end car, and the EOT device.
3. There appear to be a number of root causes for hose separations.
4. Hose separations would seem to be a function of one or both:
   - Site-specific issues, possibly track features, condition, grade crossing condition
   - Car-specific issues including:
     - Component condition
     - Possible manufacture/fitting/setup
     - Design
   - Accidents
5. Tests of specifically identified bad actor cars do not readily reveal a root cause.
6. A more fundamental approach may have to be taken.

Interim Recommendations and Future Plans

1. Conduct tests on the "prime components" (2 hoses) to establish different hose assemblies/brackets:
   a. A "natural' pitch for the hoses (d vs. h, in Figure 5)
   b. The uplift force, or disengaging force, F, (Figure 5) as a function of d, h, and the end constraints provided by different assembly types.

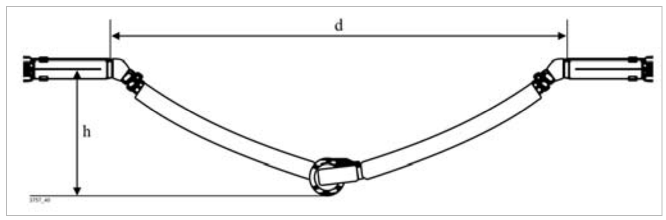

Figure 5.

2. Compare results with standards and field condition.
3. Determine the relationship between d and h, and the hose strap length and heights to the coupler and the rail.
4. Determine whether the minimum distance from rail to the hose fitting (5 to 6 inches, empty or loaded) is sufficient under long-car conditions as well as allowable suspension stiffnesses, vertical track variations, and grade-crossing conditions.
5. Conduct yard inspections of autoracks to determine variations in condition, setup, and design.
6. Conduct tests to establish the relationship between:
   a. The possible vertical interference between hose and grade crossing and impacting speed for a specific static uplift force, F.
   b. Carbody end height and grade crossing height in service through over the road tests.

References

1.Tournay, Harry M., Tom Guins and Robert Cartwright. August 2008. "Pareto Analysis of the Causes for In-service Brake Failures," *Technology Digest* TD-08-030, AAR, TTCI, Pueblo, CO.

2. Association of American Railroads. 2008. *Field Manual of the AAR Interchange Rules*, Washington, DC.