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Service Stability Testing of Suspect Brake Equipment – Part 2

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Summary

Transportation Technology Center, Inc. (TTCI) tested air brake control valves removed from 47 cars suspected of causing multiple undesired emergency brake applications (UDEs). It also tested 13 new or reconditioned brake control valves using special stability tests designed to replicate the type of short duration brake pipe pressure (BPP) fluctuations that are thought to be the cause of most UDEs (without other obvious causes such as an air hose separation). Results underscore the importance of the Single Car Air Brake Test (SCABT) and thorough brake system inspections. Many of the suspect valves, particularly those from cars with no obvious problems identified during SCABT and inspection, responded similarly to new and reconditioned valves during the special stability tests.

Most of the valves that showed the least stable performance were removed from cars that failed the SCABT and/or were found to have a condition that could have potentially affected the brake pipe (also known as the trainline) during inspection. Many of these least stable valves were older, un-stabilized emergency valve portions that had not received the stabilization retrofit.

The BPP reduction rates that produced an emergency response in the most sensitive valves during the special stability testing approached levels measured during previous slack action and air brake testing. This indicates that these valves could potentially produce a UDE response in the presence of the right combination of conditions (air brake service application plus slack action). Air in a train's brake pipe has sufficient momentum to generate fluctuations in the BPP when subjected to the accelerations of train slack action. The path forward includes further investigation into how trainline issues may be contributing to UDEs. TTCI also will explore options for accelerating the removal of older, un-stabilized valve types from the fleet.

The work described in this *Technology Digest* was conducted as part of a root cause analysis of UDEs under the Association of American Railroads' Strategic Research Initiative on Improved Brake System Performance.



INTRODUCTION AND BACKGROUND

Line-of-road failures due to undesired emergency brake applications (UDEs) (without other obvious causes such as an air hose separation) were investigated through special stability testing of brake control valves removed from cars suspected of causing multiple UDEs. Performance of such valves was compared against the performance of new and reconditioned valves.

Previous research examining the causes and mitigation methods for UDEs has been summarized in a *Technology Digest*.¹ One of the conclusions from past work was that most UDEs were caused by fluctuation of brake pipe (also known as trainline) pressure (BPP) due to slack action associated with train handling.

Newer emergency brake portions, such as the ABDX and DB20, include design features intended to make them less prone to UDEs. Older style valves (ABD and ABDW) are no longer in production but can receive stabilization retrofits (ABDS and ABDWS) during reconditioning to improve their UDE performance. Cars with more than 75 feet of brake pipe make use of special brake valves, such as ABDXL and DB-20L, specifically designed to accommodate this difference.

The Single Car Air Brake Test (SCABT) is a standardized test for the brake system on a freight car.² The SCABT includes tests for the stability of the control valve during normal applications and emergency applications. These tests are conducted using different size orifices to vent the BPP at different rates over multiple seconds. In contrast, the BPP fluctuations produced by train slack action last only fractions of a second.

Until recently, identifying cars suspected of causing UDEs has been extremely difficult. As part of the AAR's Asset Health Strategic Initiative, railroads are now sending consist lists of trains that experience UDEs to Railinc so that suspect cars that repeatedly appear in multiple trains with UDEs can be identified.³ Early in this process, suspect UDE cars were removed from service, inspected according to a checklist, and tested according to the SCABT.

Measurements of the BPP fluctuations induced by train slack action indicate that slack action alone may not approach levels of concern for a UDE, even when considering the performance of control valves suspected of having a history of UDEs. However, slack action in combination with minimum service brake applications, was noted to produce BPP fluctuations as high as 18.5 psi/sec over a 75 msec duration.⁴

VALVE TESTING

TTCI received and tested air brake equipment from 47 suspect UDE cars. Regardless of the SCABT results during the railroad inspection, the brake equipment was removed from the car and sent to TTCI. Each set of service and emergency control valves removed from a suspect UDE bad actor car was installed on TTCI's single car test rack. They were subjected to automated 4-port SCABT and special service stability testing with BPP fluctuations. The test rack was configured to simulate a car with 52 feet of brake pipe for most tests and reconfigured to simulate a car with 79 feet of brake pipe when testing components removed from long cars.

The emergency valve portions were grouped in one of four categories. Table 1 shows a breakdown of the valves by type and category including a generic labeling used later in this *Technology Digest*. Service portions are not listed in Table 1 as they are less likely to affect stability and occurred in many combinations with the suspect UDE emergency portions.

Valves in the New/Recon category were brand new or recently reconditioned and intended to provide reference results for comparison. For the valves no longer in production, only reconditioned valves could be procured and tested. For the valve types currently in production (ABDX, ABDXL, DB-20, and DB-20L), both new and reconditioned units were tested. A new service portion from each of the two represented manufacturers was obtained for testing so that both the service and emergency valve portions were produced by the same manufacturer for the New/Recon testing.

The other categories include the valves removed from suspect UDE cars and indicate the findings from car inspections or standardized testing: No Obvious Problem (NOP), SCABT, and Trainline. Each emergency portion from the suspect UDE cars was tested with the service portion it was mated with while in service. Valves in the NOP category were removed from cars that passed the SCABT testing conducted by the railroad during the inspection, passed the automated 4-port SCABT conducted by TTCI, and the inspection by the railroad did not reveal a clear cause for UDE issues.

Valves in the SCABT category failed at least one SCABT conducted by the railroad and/or TTCI for any reason. Valves in the Trainline category typically passed the SCABT but the inspection conducted by the railroad revealed either a leak somewhere in the brake pipe or an issue with the end arrangement that could potentially affect UDE performance.

Table 1. Valve details

Emergency Brake Valve Portion Trade Name	Valve Type Label	Count by Category				Total Count
		New/Recon	NOP	SCABT	Trainline	
ABD	1	1	0	6	3	10
ABDW	2	1	1	4	1	7
ABDS/ABDWS	3	2	2	2	0	6
ABDX/ABDXR or DB20*	4	3	8	1	0	12
	5	2	11	3	1	17
ABDXL or DB20L*	6	2	0	1	0	3
	7	2	1	1	1	5
Sum		13	23	18	6	60

*The label for these valve types is intentionally ambiguous

Special Stability Testing

TTCI conducted special stability testing of each set of control valves with a programmable pressure control device. Multiple time history input files were developed which reduced the BPP from a fully charged condition of 90 psi to a target pressure between 80 and 88 psi over a target period between 50 and 500 msec. A minimum of 33 BPP reductions were provided to each set of brake valves with the goal of producing an emergency response in approximately half of the tests. Brake equipment was subjected to the testing at room temperature and again inside TTCI’s cold room between 15°F and 20°F. Additional detail about the testing has been described previously.⁵

The lowest reduction rate that caused an emergency response was considered the critical BPP reduction rate for each emergency portion tested. Brake control valves require a finite increment of time to react to changes in BPP. After evaluating five different time increments, from 10- to 100-msec, the most appropriate time increment for analysis was determined to be 75-msec. In more than one instance, valves were observed to react to BPP fluctuations in less than 100msec, but never less than 75msec. Thus, all BPP reduction rate data presented here has been processed using a 75-msec moving average window.

RESULTS AND INTERPRETATION

A general regression model was created to evaluate the influence of various factors (valve type, category, test temperature) and interactions of these factors. The adjusted R² (variation explained in the model) for the model was 56.5 percent, which implies that substantial sources of variation were not explained by the model. At

the 95 percent confidence level, the following factors were found to be significant:

- Valve type
- The interaction between valve type and ambient test temperature
- The interaction between valve type and category

Figure 1 shows an interval plot grouped by valve type and test temperature. Figures 2 and 3 show interval plots grouped by valve type and valve category. In these plots, pooled standard deviation is used to calculate 95 percent Bonferroni confidence intervals as shown by the ranges of the bars. Coloring of the data indicates membership in statistical groupings: red and green groups are statistically different from each other, blue is not statistically different from red or green. The gray dashed horizontal line in each figure indicates the maximum BPP reduction rate observed during previous slack action and air brake testing.⁴

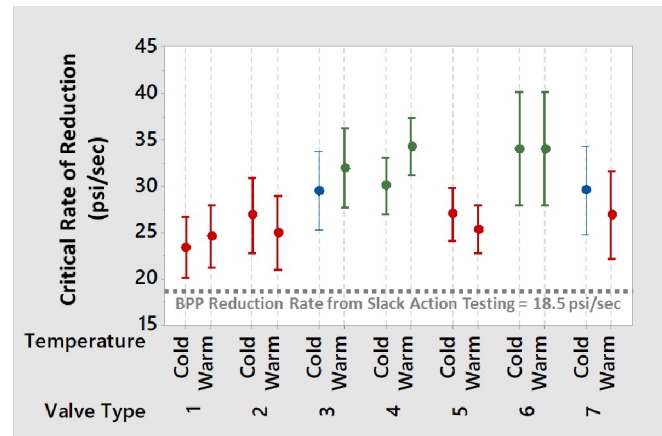


Figure 1. Interval plot grouped by valve type and test temperature

Different valve types had different levels of stability as evidenced by higher or lower critical rates of BPP reduction as observed in Figures 1, 2, and 3. Valve types 1, 2, and 5 were grouped together with the lowest critical rates of BPP reduction (red) in Figure 1, making them the most susceptible to UDE in the presence of BPP fluctuations. Valve types 4 and 6 had the highest critical rates of BPP (green) and therefore should be the least susceptible to UDE in the presence of BPP fluctuations.

Cold temperatures had different effects on different valve types, as shown in Figure 1. For any particular valve type, the difference in results between cold and warm test temperatures were not statistically different. When considered altogether however, the interaction between valve type and test temperature was significant.

Figures 2 and 3 display the same data organized differently to highlight different relationships. These figures show that new and/or reconditioned type 1, 2, and 5 valve types generally are more stable (blue or green) than these same types of valves removed from UDE suspect cars (red in most cases). Valve types 4 and 6 were in the most stable group (green) regardless of whether the valves were new/reconditioned or removed from UDE suspect cars.

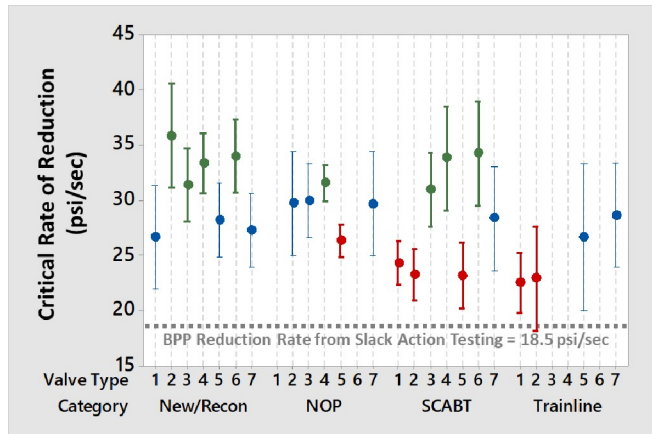


Figure 2. Interval plot grouped by valve type then by valve category

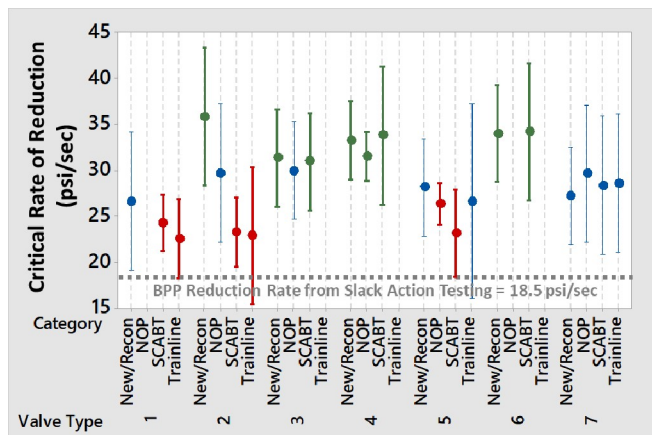


Figure 3. Interval plot grouped by valve category then by valve type

In Figures 2 and 3, the least stable valves (red) appear only in the categories associated with UDE suspect cars (NOP, SCABT, and Trainline). For UDE suspect cars with no obvious problem found during inspection and standardized testing, the special stability testing likewise could not find an obvious issue with the valve in most cases. For valves that failed the SCABT at some point, the special stability testing produced mixed results; valve types 1, 2 and 5 fell into the least stable grouping (red) but valve types 3, 4, and 6 fell into the most stable grouping (green). For valves that were removed from UDE suspect cars that showed a potential issue with the trainline, the

special stability testing indicated that the valves were in the least stable grouping (red) in some cases. This may imply that the combination of a trainline issue and a slightly sensitive valve can produce UDEs.

In Figures 2 and 3, some of the confidence bands of the critical reduction rates approach and/or extend below the BPP fluctuation rates recorded in previous slack action and air brake testing. This indicates that these valves could produce a UDE response in the presence of the right combination of conditions.

CONCLUSIONS AND FUTURE WORK

Special stability tests of brake control valves removed from railcars suspected of repeatedly causing UDEs in comparison with new and reconditioned brake control valves showed the following:

- Testing cars according to the SCABT and performing a thorough inspection of the brake system are important troubleshooting tools. Many of the suspect valves responded similarly to new and reconditioned valves when exposed to short duration BPP fluctuations that are thought to produce UDEs. This was particularly true of valves from cars with no obvious problems identified by SCABT and inspection.
- Regarding the least stable valves tested:
 - Most were removed from cars that failed the SCABT and/or had a condition that could have potentially affected the trainline. TTCI will further investigate how trainline issues may be contributing to UDEs.
 - Many were older, un-stabilized emergency valve portions (ABD and ABDW). TTCI will explore options for accelerating the removal of these valve types from the fleet.

References

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