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Cold Weather Brake Valve Performance and Built-Up Tread Wheels

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Summary

As part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program to prevent wheel failures and extend wheel life, two studies on the effects of cold weather on the formation of built-up tread on wheels have been conducted. Data from the AAR's Car Repair Billing database was used to determine the seasonal effects of built-up tread removals. Brake valves from cars with built-up tread were tested at room temperature and at cold temperatures. The following conclusions were reached:

- Seasonal changes influence built-up tread; 72 percent more wheels are replaced for built-up tread in the winter than in the summer.
- Wheel position in a car influences built-up tread; 78 percent more wheels are replaced for built-up tread in Truck B than in Truck A.
- A study of brake valves removed from eight cars that developed built-up tread in the winter found that the valves leaked air into the brake cylinder for all eight cars. Six of the cars had valves that leaked air into the brake cylinder only under cold-testing conditions.
- A second study of brake valves removed from cars with built-up tread found that two out of nineteen valve portions exhibited behavior that could cause built-up tread. This second study was conducted in cold temperatures with an air dryer and at room temperature.

This testing has shown that some valve portions react differently depending on the environmental temperature. This could explain at least some of the winter increase in built-up tread removals. It is not practicable to conduct all brake-valve testing under cold conditions. However, the addition of wayside wheel temperature measurement devices provides railroads with an opportunity to evaluate braking performance of cars under a variety of temperatures throughout the year. This in turn, could be used to identify select cars for maintenance inspection.

Built-up metal higher than 1/8 inch on the wheel tread is condemnable under AAR rules. While built-up tread is not a leading cause of wheelset repairs, it deserves study because it is the second leading wheel-related cause of accidents in the Federal Railroad Administration safety database. Built-up tread is commonly thought to occur through the sliding action of a wheel on a rail. Therefore, problems with the braking system are of interest in trying to reduce the incidence of built-up tread.

Special acknowledgement to former UP employee David McConnell for his contribution to this TD.



INTRODUCTION

As part of the AAR’s Strategic Research Initiatives Program to prevent wheel failures and extend wheel life, two studies on the effects of cold weather on the formation of built-up tread on wheels have been conducted. Data from the AAR’s Car Repair Billing (CRB) database was used to determine the seasonal effects of built-up tread removals. Brake valves from cars with built-up tread were tested at room temperature and at cold temperatures.

BACKGROUND

Built-up metal higher than 1/8 inch on the wheel tread is an AAR condemnable condition under Rule 41, why made code 76.¹ This billing code typically accounts for less than 2 percent of the annual wheelset removals in the CRB database.² However, built-up tread deserves study because it is the second leading wheel-related cause of accidents in the Federal Railroad Administration safety database.³

Built-up tread is commonly thought to occur through the sliding action of a wheel on a rail. Therefore, problems with the braking system are of interest in trying to reduce the incidence of built-up tread. Figure 1 shows a wheel that has been slid and the resulting metal build-up on the tread.



Figure 1. Wheel with Built-up Tread

REPAIR DATA ANALYSIS

The repair data in the CRB database was used to identify patterns in the removal of wheelsets due to built-up tread. Figure 2 shows the average count of wheels removed for built-up tread in each quarter of the years 2007 through 2009. Seventy-two percent more wheels are removed due to built-up tread in cold weather during the first quarter (1778) compared to warm weather in the third quarter (1031). Figure 2 also shows that there are some discrepancies in terms of the location of the wheels removed for built-up tread. Wheels located in truck B (axle positions 1 and 2) are more prone to built-up tread than wheels located in truck A (axle positions 3

and 4). Interestingly, wheels located in Truck B average approximately 300 to 400 more built-up tread removals per quarter regardless of the weather, suggesting that a combination of seasonal and nonseasonal effects are at the root cause of built-up tread removals.

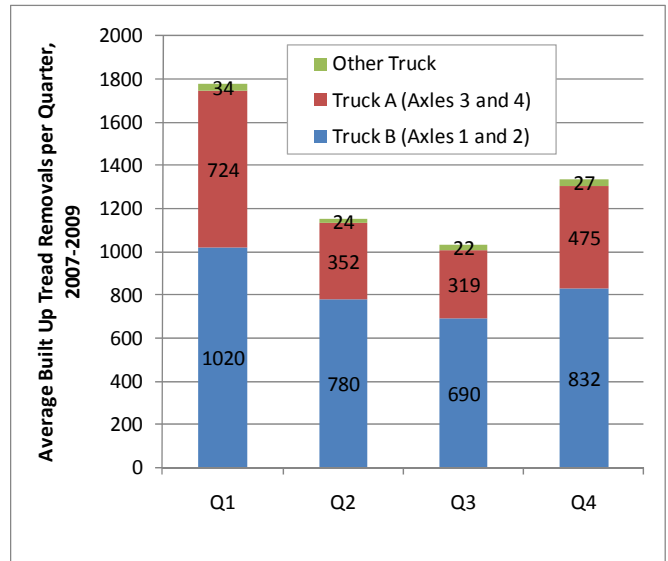


Figure 2. Seasonal Built-up Tread Removal

Several theories could explain this seasonal effect:

- Moisture in the air supply could freeze components in the brake valve in cold weather.
- Cold air temperatures affecting the pneumatic portion of the braking system through the stiffening of flexible components
- Ice build-up on brake rigging affecting brake releases or the proper distribution of shoe forces during brake applications
- Seasonal changes in wheel/rail adhesion levels affecting the probability of wheel slide for a given brake ratio

Figure 3 shows a pie chart of the axle position of built-up tread wheel removals within the car for the years 2007 through 2009. The percentage of built-up tread wheels in truck B is substantially higher than the percentage of built-up tread wheels in Truck A or other trucks in the case of multi-unit cars. The axle positions within each truck have similar levels of built-up tread removals. At least two theories could explain the discrepancy in the location of built-up tread wheels:

- The hand brakes on cars with truck mounted brakes only apply braking force to wheels in Truck B. Additionally, the hand-brake ratio for the wheels in Truck B of a car with truck mounted brakes is twice as high compared to the hand-brake ratio of all wheels in a similar car with body mounted brakes.
- The brake cylinder on cars with foundation rigging is located nearest to Truck B. The addition of

mechanical components in the brake rigging between the brake cylinder and the wheels in Truck A may produce a lower effective brake ratio at Truck A, especially as rigging components age and wear.

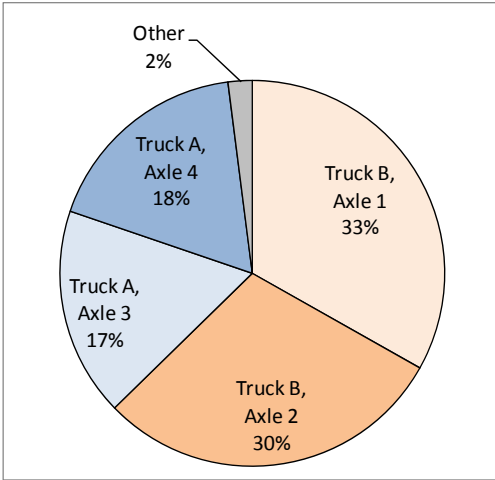


Figure 3. Location within Car of Built-up Tread Removals

BRAKE VALVE TESTING

The influence of a cold environment on the performance of brake valves was investigated in two brake valve studies. These studies focused on the potential for the valves to produce excessive air pressure in the brake cylinder due to stiffening of flexible air-sealing components such as gaskets. Unintended air leakage into the brake cylinder increases the likelihood of wheel slides and built-up tread.

First Study

In the first study conducted by the Union Pacific Railroad, brake valves from eight cars that developed built-up tread wheels in the wintertime were removed from the cars and tested on a brake simulator that emulates a 60-foot brake pipe car in a climate controlled environment. A single car test (SCT) was performed on each valve portion using an automated test device.⁴ In addition to the SCT, each valve portion was exposed to two brake pipe pressure reductions (minimum service application and 20 psi reduction) that were held for 10 minutes. Each valve portion was installed on the test rack with a known good valve portion, so that each valve portion could be assessed individually. Tests were conducted at room temperature (72°F to 74°F) and repeated at a cold temperature between 13°F and 26°F. An air dryer was used to prevent ice formation inside the valve portions during the cold SCT.

The valve testing revealed that all eight cars had at least one valve portion that caused higher than intended brake cylinder pressure under some conditions. In the faulty valve portions, the brake cylinder pressure typically leaked up to equalize with the brake pipe pressure. Temperature had a strong influence on the resulting brake cylinder pressure. Six of the cars had valves that leaked air into the brake cylinder only under cold testing conditions. One car had a valve portion that leaked air into the brake cylinder only under room temperature

conditions, and one car leaked air into the brake cylinder at all temperatures tested. Table 1 lists the test results.

Only one of the nine valve portions (car 7 emergency portion) that leaked air into the brake cylinder passed the SCT both at room temperature and under cold conditions. Three service portions (cars 1, 2, and 4) passed the SCT and maintained proper brake cylinder pressure at room temperature, but failed the SCT and leaked air into the brake cylinder under cold conditions. Temperature did not affect the SCT result for the emergency portions in this study; all of the emergency portions either passed the SCT at both temperatures or failed the SCT at both temperatures.

Table 1. Results of the First Brake Valve Study

Car	Portion	Single Car Test Result		Brake Cylinder Pressure At Desired Level After 10 Minutes	
		Warm	Cold	Warm	Cold
1	Serv.	Pass	Fail	Yes	No
1	Emer.	Pass	Pass	Yes	Yes
2	Serv.	Pass	Fail	Yes	No
2	Emer.	Fail	Fail	Yes	Yes
3	Serv.	Fail	Fail	No	No
3	Emer.	Pass	Pass	Yes	Yes
4	Serv.	Pass	Fail	Yes	No
4	Emer.	Fail	Fail	Yes	No
5	Serv.	Fail	Fail	No	Yes*
5	Emer.	Not tested			
6	Serv.	Pass	Pass	Yes	Yes
6	Emer.	Fail	Fail	Yes	No
7	Serv.	Pass	Pass	Yes	Yes
7	Emer.	Pass	Pass	Yes	No
8	Serv.	Pass	Pass	Yes	Yes
8	Emer.	Fail	Fail	Yes	No

* The brake cylinder pressure was observed to leak off. While this condition is not desired, it would not result in built-up tread.

Second Study

A second study of the effects of cold weather on the functioning of brake valves was conducted recently by Transportation Technology Center, Inc. The valves in this study were also removed from cars reported to have wheels with built-up tread. A total of 19 valve portions were tested. Ten of the valve portions were mated service and emergency portions from five cars. Due to illegible car numbers on some castings, the mates for the remaining nine portions were undetermined.

The group of valves used in the second study was subject to contamination from water and particulates in the interim time between removal from the car and arrival at Transportation Technology Center. The inshot check valve was missing from three of the emergency portions. A check valve from another emergency portion was used.

A SCT was performed on each valve portion using a manual test device. Each valve portion was installed on a car with known good valve portion, so that each valve portion could be assessed individually. Tests were conducted at room temperature (approximately 72°F).

Four months after the room temperature testing, the valve portions were again mated with known good valve portions and tested on the air brake rack in TTCI's cold room at -15°F. The rack was configured to emulate a car with 64 feet of brake pipe. An air dryer and filter were used to prevent ice formation inside the valve portions during the cold SCT. Figure 4 shows the air brake rack used in the testing.



Figure 4. TTCI's Cold Room Brake Rack

Three service portions and one emergency portion failed the room temperature SCT. One of these three service portions failed the SCT due to increasing air pressure into the brake cylinder, which could potentially be the cause of built-up tread wheels. The other 15 valve portions passed the room temperature SCT.

Five service portions and six emergency portions failed the SCT conducted at -15°F. All of the portions that failed the room temperature SCT also failed the cold air SCT. Nine of these failures were discovered during the system leakage test. The service portion that failed the original room temperature SCT due to increasing brake cylinder pressure failed the cold air SCT due decreasing brake cylinder pressure. Another service portion failed the release after emergency test under cold conditions. Figure 5 shows the test results.

Five of the valve portions were retested on the brake rack following the cold air testing. The chillers in the cold room were turned off, and the room was allowed to warm overnight to approximately 60°F. Four emergency portions that passed the initial warm SCT then failed the cold SCT, due to system leakage, were retested. Of these four portions, one passed the repeat warm SCT, one failed the repeat warm SCT due to increasing brake cylinder pressure, and two again failed the system leakage test. The service portion that initially passed the SCT then failed the Release Test after Emergency under cold conditions and again failed when retested under warm conditions.

The second study showed that two out of nineteen valve portions exhibited behavior that could explain the built-up tread found on the wheels.

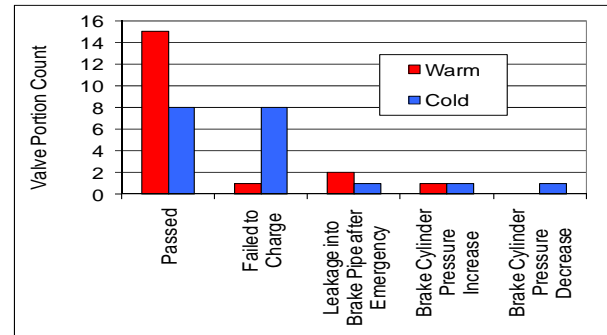


Figure 5. Single Car Test Results

DISCUSSION

This testing has shown that some valve portions react differently depending on the environmental temperature. This could explain at least some of the winter increase in built-up tread removals. It is not practicable to conduct all brake valve testing under cold conditions. However, the addition of wayside wheel temperature measurement devices provides railroads with an opportunity to evaluate braking performance of cars under a variety of temperatures throughout the year. This, in turn, could be used to identify select cars for maintenance inspection.

CONCLUSION

TTCI will continue to investigate the causes and conditions associated with built-up tread under AAR's Strategic Research Initiatives Program. Conclusions from this study are:

- Seasonal changes influence built-up tread; 72 percent more wheels are replaced for built-up tread in the winter than in the summer.
- Wheel position in a car influences built-up tread; 78 percent more wheels are replaced for built-up tread in Truck B than in Truck A.
- A study of brake valves removed from eight cars that developed built-up tread in the wintertime found that the valves leaked air into the brake cylinder for all eight cars. Six of the cars had valves that leaked air into the brake cylinder only under cold testing conditions.
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