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Improved Brake Rigging Designs to Extend Wheel Life

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Summary

As part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program to improve brake performance, Transportation Technology Center, Inc. (TTCI) has conducted tests on brake system products to determine their effectiveness in reducing lateral brake beam shift in trucks while maintaining brake functionality. Lateral shift of the brake beams is thought to be a major contributor to asymmetric wheel flange wear (AWFW) and thin flange removals, which have increased in recent years for M-976 trucks as removals for high impact wheels have reduced.

Brake products tested produced similar average and maximum brake shoe forces compared to the baseline configuration during tests on tangent and curved track with brake applications levels from minimum service to full service. The brake products reduced lateral shift of the beams without a large reduction in the brake shoe force

Testing was conducted using a fully loaded aluminum coal gondola car equipped with AAR M-976 approved trucks and body-mounted brake rigging configured in a rod-through-bolster arrangement. The test was designed to test the worst-case scenario conditions for induced binding of brake beams, which could reduce brake forces or lock the brakes in the applied position, producing skidded wheels. Test setup included:

- Thicker brake beam unit guide wear liners at all four locations in the truck rather than just the two diagonally opposite corners
- Brake beams of maximum length
- Wide flange wheel profiles

Although these products reduced the lateral shift of the brake beams, this testing does not prove the ultimate effectiveness of the products to reduce AWFW, because lateral brake beam shift is not the only factor inducing AWFW. Other factors, for example, are shoe width and rate of flange wear. TTCI plans to monitor revenue service tests already underway involving some of the products described in this digest and will report on the effectiveness of the products to reduce AWFW.

Refer to TD-12-015 for results of a previous test under the SRI program to improve brake performance.¹



INTRODUCTION

Continuing investigations under the AAR’s Strategic Research Initiatives Program to improve brake performance, TTCI recently conducted tests of products designed to reduce the lateral shifting of brake beams in trucks. Wheelset removals for thin flange have increased in recent years for some car series.² Lateral shift of the brake beams is thought to be a major contributor to AFWF and thin flange removals.

BACKGROUND

In 2010, TTCI published several *Technology Digests* on the phenomenon of AFWF and the possible causes of AFWF, including the lateral shift of brake beams in trucks. The following was found:^{3,4,5,6}

- Asymmetries in some common brake rigging designs cause the two brake beams in a truck to migrate laterally in opposite directions when the brakes are applied.
- Lateral contact between the brake shoe and the wheel initiates a wheel tread wear pattern that is not symmetric between the two wheels on a wheelset eventually resulting in the loss of steering ability and wheel flange wear.
- Most wheelsets condemned for thin flange have AFWF.

In response to the findings, multiple industry suppliers produced products designed to reduce the lateral shifting of brake beams. These products can generally be described as modified brake beam unit guide wear liners, modified brake beams, or modified brake shoes.

Brake beam unit guide wear liners provide a wear-resistant and replaceable liner between the side frame and the brake beam. The wear liners can also be used to reduce the lateral clearance between the brake beam end extensions and the unit guides in the truck side frames to provide more effective lateral guidance. Nominal material thickness for these wear liners is 0.188 (3/16) inch. Two suppliers have produced nonmetallic wear liners with increased material thickness on the lateral surface(s). One supplier has produced metallic wear liners with a laterally centralizing spring. Another supplier has produced brake beams with a lateral spring in the end extension on one side. These beams can be used in a standard rigging arrangement or with a special link that controls the pitch of the brake beam.

Asymmetric brake shoes were offered for testing by one supplier. These shoes are wider on the side of the brake shoe nearest to the wheel flange to reduce the lateral clearance between the wheel and the brake beam, enabling the wheelset to provide lateral guidance to the beam.

TD-12-015 contains the results of the products tested at Transportation Technology Center in 2012.¹ Figure 1 is a reprint of a table in TD-12-015 and shows a summary of the results from measuring lateral shift.

The testing showed that liners reduced the lateral shift and did not significantly impact the brake shoe force on the wheel. Other methods of reducing lateral shift — lateral spring and asymmetric brake shoes — did not show as large of a reduction in lateral shift from the baseline.

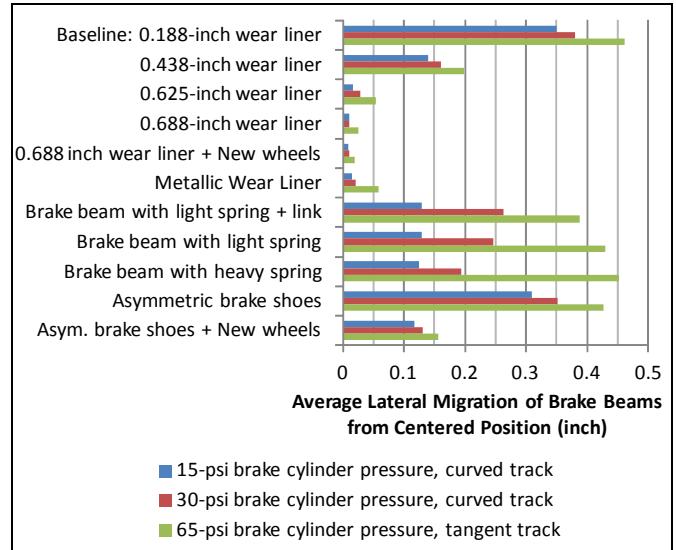


Figure 1. Brake Beam Lateral Shifting (reprinted from TTCI TD-12-015)

TEST DESCRIPTION

Testing was conducted using a modern aluminum coal gondola car equipped with body-mounted brake rigging configured in a rod-through-bolster arrangement. The car was loaded for all testing.

As suggested by the M-976 Task Force, the additional tests were conducted using the following alternative truck configurations in 2013:

- A different style M-976 truck than the style tested in 2012 with rubber pads
- A standard 3-piece truck

To increase the likelihood of binding under truck warp conditions:

- Liners were installed at all four locations of the truck, rather than just the two in diagonally opposite unit guides.
- Both of the standard brake beams in the B-end truck were at the maximum acceptable range of the AAR limit for overall beam length (69 11/16 inch).
- The wheelsets used in this test were cut to the AAR-1B wide flange profiles.

Table 1 lists the wear liners, brake beams, and wheel profiles used for each test configuration. Note, the 0.688 inch wear liners are also referred to as the thickest wear liners in this TD.

Table 1. Test Configuration Details

| Configuration | Truck | | Brake Beam Length | | Wheel Flange Thickness | | Unit Guide Wear liner Thickness | | | Brake Shoe | |
|------------------------------|--------|-------------------------------------|-------------------|------|------------------------|------|---------------------------------|------------|-------------|------------|------------|
| | S-2-HD | Split Wedge with S2-86 Adapter Pads | Max. | Min. | Max. | Min. | Standard | 0.688 inch | Leaf Spring | Standard | Asymmetric |
| Baseline, M-976 | | X | X | | X | | X | | | X | |
| Thickest Wear Liner, M-976 | | X | X | | X | | | X | | X | |
| Metallic Wear Liner, M-976 | | X | X | | X | | | | X | X | |
| Baseline, 3-Piece | X | | X | | X | | X | | | X | |
| Thickest Wear Liner, 3-Piece | X | | X | | X | | | X | | X | |
| Metallic Wear Liner, 3-Piece | X | | X | | X | | | | X | X | |

Data was collected at the B-end of the car where the brake products were installed. All test runs were conducted with the B-end of the car in the leading position. Each brake configuration was tested dynamically by applying and releasing the brakes while the car was in motion.

Critical data collection channels included brake cylinder pressure, lateral brake beam displacement, and brake shoe forces at each of the four brake shoes in the B-end truck using instrumented brake shoes.

All dynamic tests were conducted at the Transportation Technology Center, Pueblo, Colo., on the Wheel Rail Mechanism (WRM) loop over 3-, 4-, 5-, 7½-, 10-, and 12-degree curves and adjacent tangent track zones. Pressurized air was piped directly into the test vehicle’s brake cylinder.

Brake applications and releases of 15- and 30-psi brake cylinder pressure were made in the curves to simulate minimum service and moderate braking. Brakes were applied for approximately 25 seconds in the body of each curve and then released. Brake applications and releases of 65-psi brake cylinder pressure were made in a tangent track zone to simulate full-service braking. For each configuration, braking data was collected during three clockwise and three counterclockwise laps around the WRM loop.

RESULTS

Testing was designed to provide data regarding how each product affected lateral brake beam shifting while maintaining brake functionality.

The lateral migration of the brake beam measured more than 0.3 inch in the previously reported test for all cylinder pressures, using the baseline liners (see Figure 1).¹ Using a

different truck and wheel profile in the 2013 test, the largest average lateral migration was just over 0.2 inch, using the baseline liners. The 3-piece truck had approximately the same amount of lateral migration. Figure 2 shows the average lateral migration data for all the configurations tested in 2013.

The wear liner products tested reduced the average lateral movement compared to the baseline wear liners. For the M-976 style trucks, the average lateral migration, when using either of the tested liners, was less than 0.1 inch. The average lateral displacement of the brake beams also was reduced for the 3-piece truck. The highest average lateral displacement, when the tested liners were installed for either truck, occurred when the thickest liners were used in the 3-piece truck. The values for the tested liners are consistent with results from the previous test with a different M-976 truck.¹

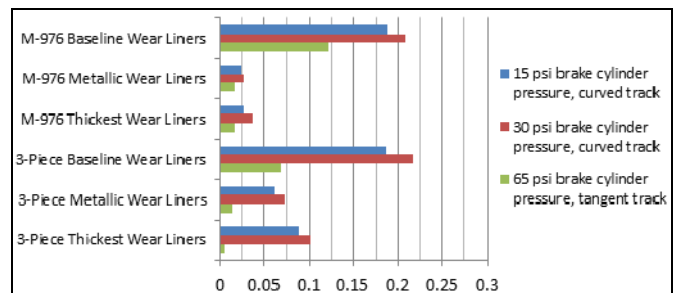


Figure 2. Average Lateral Migration of Brake Beams

The brake functionality of the prototype products was evaluated using average and maximum brake shoe forces. The average brake shoe force of each configuration was compared to the average brake shoe force in the baseline condition. This

gives an indication of the overall effect of any additional friction or changes in efficiency due to the design changes.

The average brake shoe forces for the prototype liners showed no significant differences from the baseline condition. Trucks in both tests performed similarly when compared to individual baseline truck values. All conditions had an average brake shoe force difference of less than 10 percent of the baseline condition. The 3-piece truck conditions were less than 10 percent, except for the condition with the 15-psi application and thickest wear liners.

As a note, at lower pressures, differences between the baseline liners and tested liners are more evident when looking at a percentage, because the baseline average force was lower. An example of this is the average shoe force in the 3-piece truck using the thickest liners. The 16 percent increase in average force equates to less than 100-pounds between the baseline and tested liners.

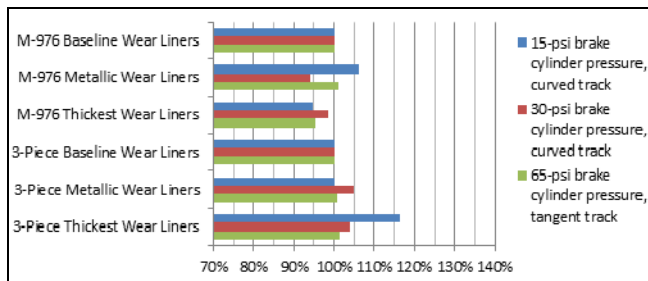


Figure 3. Average Brake Shoe Force as a Percentage of that Truck with Baseline Wear Liners

If the maximum shoe force changed due to the reduced lateral clearance of the brake beams to the side frames or the reduced lateral clearance changed the behavior of the brake shoes and wheel flanges, there could be concerns about:

- The beam being pinched due to a truck warp could result in no braking or undesired braking
- The brake shoes forced against the wheel flange during truck warp could cause wheels to overheat or skid

Figure 4 shows the values for the maximum brake shoe force. The maximum individual brake shoe forces were evaluated by determining the highest individual brake shoe force developed for each configuration and comparing it to the highest individual brake shoe force developed for the baseline condition. The largest percentage difference between the baseline liner and a tested liner was the metallic wear liner on the M-976 truck. There was just over a 15-percent difference between the maximum shoe force with the baseline wear liners and the metallic wear liners. Also during the 15-psi application for the metallic wear liner and the 3-piece truck, the maximum brake shoe force was about 10 percent less than the baseline condition. In both cases, this is not a major concern because it occurred during the 15-psi application. All the other applications for both trucks were no more than 10-percent different from the baseline condition.

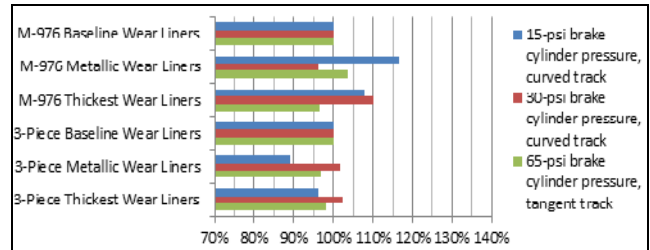


Figure 4. Maximum Brake Shoe Force as a Percentage of that Truck with Baseline Wear Liners

CONCLUSIONS

Summarizing the information from the 2012 and 2013 testing, the tested brake beam unit guide wear liners designed to reduce or eliminate lateral clearance between the brake beams and the side frames through increased material thickness or a spring did reduce the lateral motion of the beams compared to the baseline wear liners. There was little effect on the average brake shoe force, and the lateral migration was reduced compared to the baseline wear liner.

Although the products reduced the lateral shift of the brake beams, this testing does not prove the ultimate effectiveness of the products to reduce AFWF. Long term field trials are a necessary step to provide data regarding the effectiveness of the products to reduce AFWF. Such field trials may also produce valuable information regarding performance differences related to product design.

FUTURE WORK

At least some of the products tested by TTCI are undergoing limited field evaluations as approved by the appropriate AAR committees to evaluate the effectiveness of the products to reduce AFWF. TTCI plans to monitor results from these tests and issue future TDs on the results as they become available.

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