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# Test Results of Products Designed to Reduce Lateral Shifting of Brake Beams

Scott Cummings

## Summary

Transportation Technology Center, Inc. (TTCI) recently tested brake system products to determine their effectiveness in reducing lateral brake beam shifting while maintaining brake functionality as part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program to improve brake performance. Lateral shifting 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 some car series.

All of the 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. With regard to the effectiveness of the various products to reduce lateral brake beam shift:

- The prototype brake beam unit guide wear liners were highly effective.
- The beam pitch-restraint linkage did not produce an appreciable change.
- The brake beams with a lateral spring in one brake head were effective at minimum service and moderate brake applications.
- The asymmetric brake shoes were effective when paired with wheels with AAR-1B wide flange profiles.

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. Worst-case (or near-worst-case) scenario conditions were used as appropriate including thicker brake beam unit guide wear liners at all four locations in the truck rather than just the two diagonally opposite corners, brake beams at the maximum acceptable range of the AAR limit for overall beam length, and condemnably thin wheel flanges to allow the brake beams to migrate as far as possible.

Although many of the products successfully reduced the lateral shift of the brake beams, this testing does not prove the ultimate effectiveness of the products to reduce AFWF; this is because lateral brake beam shift is not the only factor inducing AFWF. Other factors, for example, are shoe width and rate of flange wear. TTCI plans to conduct additional testing under controlled conditions and 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 AFWF.



**INTRODUCTION**

TTCI recently conducted tests of products designed to reduce the lateral shifting of brake beams as part of the AAR’s Strategic Research Initiatives Program for improved brake system performance. Wheelset removals for thin flange have increased in recent years for some car series. Lateral shifting of the brake beams is thought to be a major contributor to AFWF and thin flange removals. TTCI tested brake system products to determine their effectiveness in reducing lateral brake beam shifting while maintaining brake functionality.

**BACKGROUND**

As briefly summarized below from several published *Technology Digests* (TDs), Tournay has described the problem of AFWF, explained its probable causes, and offered some suggestions for remedies:<sup>1,2,3,4</sup>

- Asymmetries in 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 nonsymmetric between the two wheels on a wheelset eventually resulting in wheel flange wear.
- Most wheelsets condemned for thin flange have AFWF.

In response to the problem of AFWF, multiple industry suppliers have produced prototype products designed to reduce the lateral shifting of brake beams. The 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 act to reduce the lateral clearance between the brake beam end extensions and the unit guides in the truck side frames. 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). Another supplier has produced metallic wear liners with a lateral spring.

One 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 linkage that controls the pitch of the brake beam.

Asymmetric brake shoes were offered by one supplier. These shoes are wider on the side of the brake shoe nearest to the wheel flange.

**TEST DESCRIPTION**

Testing was conducted using a modern aluminum coal gondola car equipped with AAR M-976 approved trucks and body-mounted brake rigging configured in a rod-through-bolster arrangement. The car was loaded for all testing.

The testing was conducted with the worst-case (or near-worst-case) scenario conditions. This included installing the prototype thicker wear liners at all four locations in the truck rather than just the two diagonally opposite corners necessary to restrict the lateral motion of the beams from their typical migration direction. 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 for most of the testing were specially cut with condemnably thin flanges to allow the brake beams to migrate as far as possible. However, AAR-1B wide flange profiles were also tested with the thickest wear liners and the asymmetric brake shoes to ensure that no binding would occur under these conditions. Table 1 describes the wear liners, brake beams, and wheel profiles used for each test configuration.

**Table 1. Test Configuration Details**

| Configuration Name                  | Wear liner                    | Brake Beam  | Wheel Profile                           |                          |
|-------------------------------------|-------------------------------|---|---|--------------------------|
| Baseline                            | Standard, non-metallic        | Standard (maximum length: 69 11/16)               | Condemnably thin flanges                |                          |
| 0.438-inch wear liner               | Nonmetallic, 0.438 inch thick |   |   |                          |
| 0.625-inch wear liner               | Nonmetallic, 0.625 inch thick |   |   |                          |
| 0.688-inch wear liner               | Nonmetallic, 0.688 inch thick |   | AAR1-B wide flange                      |                          |
| 0.688-inch wear liner + new wheels  |                               |   |   |                          |
| Wear liner with spring              | Metallic, lateral spring      |   | Lateral spring on one end, linkage used | Condemnably thin flanges |
| Brake beam with light spring + link | Standard, nonmetallic         |   |   |                          |
| Brake beam with light spring        |                               | Lateral spring on one end                         |   |                          |
| Brake beam with heavy spring        |                               | Lateral spring on one end, increased spring force |   |                          |
| Asymmetric brake shoes              |                               | Standard (maximum length: 69 11/16)               |   |                          |
| Asym. brake shoes + new wheels      |                               |   |   |                          |

Data was collected at the B-end of the car where the prototype 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. Video cameras were mounted to observe the interactions between the wheel and brake shoe.

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 15 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 six clockwise and six counterclockwise laps around the WRM loop.

**RESULTS**

Testing was designed to provide data regarding each product’s effectiveness in reducing lateral brake beam shifting while maintaining brake functionality. Figure 1 addresses the lateral brake beam shifting. Except for the 0.438-inch-thick wear liners, all of the prototype wear liners completely eliminated any lateral clearance between the brake beam and the side frames. This is evident by the minimal lateral migration of the brake beams in Figure 1 for the configurations involving these wear liners. The 0.438-inch-thick wear liners allowed a small lateral clearance between the brake beam and the side frames while reducing the lateral beam migration by approximately the amount of the increased thickness compared to standard wear liners of 0.25 inch.

The brake beams with the lateral spring in the brake head reduced the lateral migration of the beams substantially at the lower brake cylinder pressures. At a full-service brake application, the lateral force on the brake beam was able to fully compress the spring. The heavier spring provided some additional benefit at 30-psi application compared to the lighter spring. The linkage did not produce much notable improvement. The asymmetric brake shoes did not make lateral contact with the wheel flanges of the condemnably thin flange wheels before the beam end extensions bottomed out in the unit guides. Thus, any differences between this configuration and the baseline should simply be considered within the range error of the test. However, when paired with AAR-1B wide flange profiles, the asymmetric brake shoes substantially reduced the lateral migration of the beams through contact with the wheel flanges.

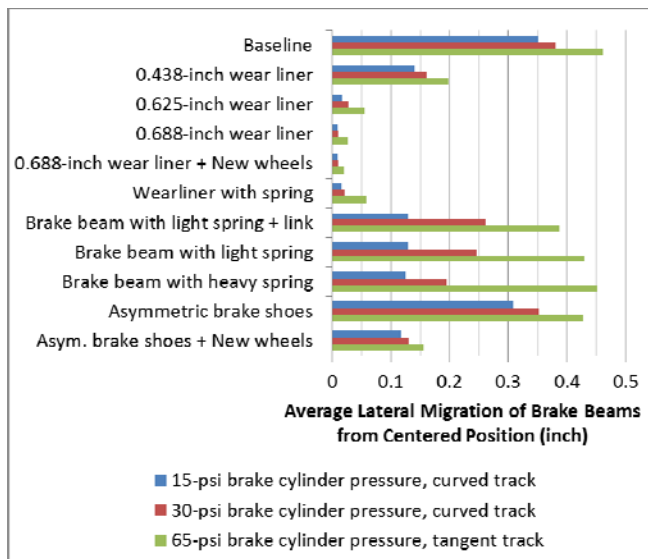


Figure 1. Brake Beam Lateral Shifting

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. All of the brake shoe forces were normalized to the nominal intended brake cylinder pressure to provide a fair comparison.

Figure 2 shows that the average brake shoe force for each configuration was greater than 90 percent of the baseline value for most applications and all applications of 30 psi or greater brake cylinder pressure. The configurations involving the brake beam with the lateral spring produced between 80 and 90 percent of the baseline values for applications of 15-psi brake cylinder pressure. These configurations required a different set of brake beams than the other configurations. Small differences inherent in the beams (other than the lateral spring) could easily have reduced average brake shoe values at such a low brake cylinder pressure. The average brake shoe forces at 15-psi brake cylinder pressure for the configurations involving the brake beam with the lateral spring were within 95 pounds of the average brake shoe force developed for the baseline condition and, thus, are not of practical concern.

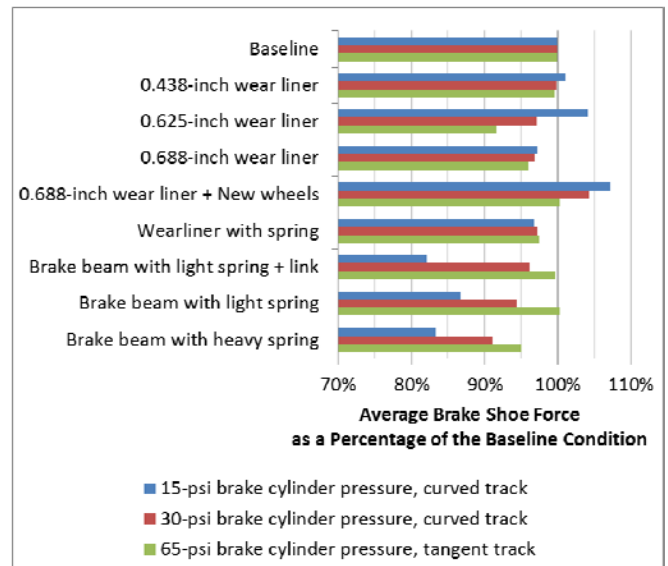


Figure 2. Average Brake Shoe Forces

Figure 2 shows several instances where the prototype wear liner configurations produced a slightly higher average brake shoe force than the baseline configuration. This is likely due to the pinching action of the side frames on the brake beams, when there is no clearance. This raises two potential issues: (1) proper brake release and (2) individual brake shoe forces reaching levels of concern. Based on review of the time history plots of the applications and releases, the brake shoe force dropped as appropriate for every brake release of every configuration.

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. Figure 3 shows these results. Two instances were observed where the highest brake shoe force exceeded 110 percent of the baseline configuration value during minimum service brake applications. These forces were within 90 pounds of the brake maximum brake shoe force developed for the baseline condition and, thus, are not of practical concern.

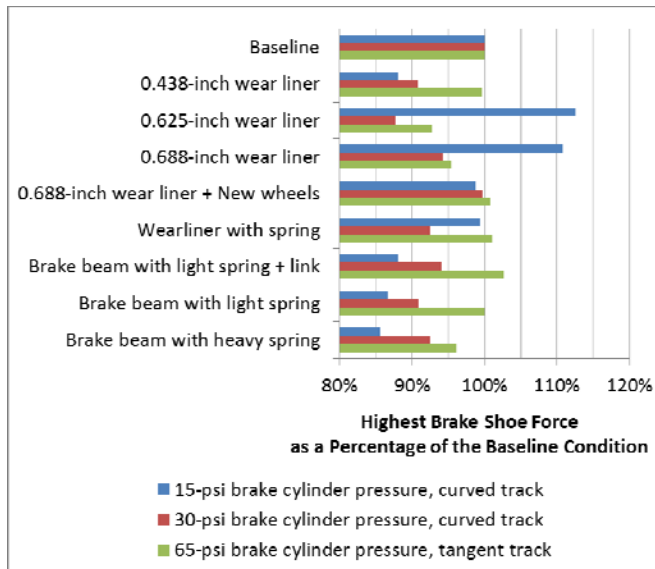


Figure 3. Highest Brake Shoe Forces

Because the instrumented brake shoes had to be removed to test the asymmetric brake shoes, there is no force data available for the asymmetric brake shoe configurations. However, as Video 1 shows, the wheel/brake shoe interface indicated that the asymmetric brake shoes did not have any problems applying and releasing the brakes as appropriate.

Video 1. Wheel/Brake Shoe Interface

## CONCLUSIONS

None of the small differences in the average and maximum brake shoe forces observed during testing of the prototype brake products compared to the baseline configuration were sufficient to cause concern. With regard to the effectiveness of the various products to reduce lateral brake beam shift:

- The prototype 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 were highly effective.
- The beam pitch restraint linkage did not produce an appreciable change.
- The brake beams with a lateral spring in one brake head were effective at minimum service and moderate brake applications.
- The asymmetric brake shoes were effective when paired with wheels with AAR-1B wide flange profiles.

Although many of the products successfully reduced the lateral shift of the brake beams, this testing does not prove the ultimate effectiveness of the products to reduce AFWW; this is because lateral brake beam shift is not the only factor inducing AFWW. Other factors, for example, are shoe width and rate of flange wear. Long term field trials are a necessary step to provide data regarding the effectiveness of the products to reduce AFWW. Such field trials may also produce valuable information regarding performance differences related to product design. For example, wider brake shoes may be able to distribute wear more evenly across the wheel tread to avoid initiating a nonsymmetric wheel tread wear pattern between the two wheels on a wheelset.

## FUTURE WORK

TTCI plans to conduct additional testing with shorter brake beams and different truck designs and conditions. At least some of the products tested by TTCI are undergoing limited field evaluations to assess the effectiveness of the products to reduce AFWW. TTCI plans to monitor results from these tests and issue future TDs on the results as they become available.

## REFERENCES

1. Tournay, H. et al. October 2010. "Asymmetric Flange Wear: Data Analysis." *Technology Digest* TD-10-034. AAR/TTCI, Pueblo, CO.
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