TECHNOLOGY DIGEST

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Brake Shoe Wear Study

by Fred Carlson

Summary

A survey of taper worn brake shoes in North American revenue service was performed to quantify the financial impact of taper worn brake shoes and to identify any trends in component design that could affect the degree of taper wear, such as truck design, truck capacity, brake beam design, and rigging design. The data in this survey, collected by Transportation Technology Center, Inc. (TTCI) , has indicated the following:

- Out of a total sample size of 3,909 brake shoes, 15.3 percent of brake shoes wore evenly, while 75.1 percent had significantly more wear on the top of the brake shoe than on the bottom. Only 1.0 percent of the brake shoes were worn more on the bottom than on the top. Based on the data, taper worn brake shoes cost the industry about $11.2 million per year due to premature brake shoe removal.
- Rod-through rigging had 17.7 percent even brake shoe wear, while rod-under had 28.3 percent even wear and hook-and-eye had 34.6 percent even wear.
- When the dead lever is connected to the car body, 26.3 percent of the brake shoes wore evenly. When the dead lever was connected to the truck bolster, 6.6 percent wore evenly.
- About 10 percent of brake beams in service are twisted such that brake shoes could wear out twice as fast on one of the two brake heads.

There appear to be significant differences in the performance of:

- Direct acting versus indirect acting truck mounted brake systems.
- The age of the brake system.
- Body-mounted brake rigging (rod-through, rod-under, and hook-and-eye.
- Dead lever connection on car body versus truck bolster.

The differences are not so pronounced when brake beam manufacturer, truck manufacturer and truck capacity are compared.

A taper worn brake shoe is one that is worn thin at the top or bottom of the shoe rather than worn evenly. This wastes brake shoe material and causes premature brake shoe replacement. This survey was a cooperative effort between TTCI, a subsidiary of the Association of American Railroads (AAR), and the Central Air Brake Club of Chicago. The AAR portion is funded as a part of the Advanced Brake Rigging Project, with goals of reducing brake shoe force variations, increasing rigging efficiency, and reducing tapered brake shoe wear.

Suggested Distribution:

- ❑ Car Department
- ❑ Planning & Analysis
- ❑ Chief Mechanical Officer
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

INTRODUCTION AND CONCLUSIONS

The data used in the TTCI tapered wear brake shoe study was gathered in cooperation with the Central Air Brake Club, Chicago, Illinois. The intent of the study was to identify the size of the problem and its cost to the industry and to identify trends that may point to problem areas that can then be addressed. By cooperating with the Central Air Brake Club, a number of people were able to sample a large number of brake shoes from a number of locations around Chicago and Colorado on a wide variety of car types.

The data collection consisted of observing brake shoe wear from outside the truck, and matching the degree of taper wear to a drawing on a chart. The drawings showed shapes of brake shoes with 12.5, 25, 37.5, and 50 percent of the new shoe material worn away as taper wear. Also noted were:

- Truck capacity
- Truck type/manufacturer
- Brake rigging type
- Brake beam manufacturer (if possible)
- Car type
- Brake shoe location
- Car built date
- Dead lever anchor position

Each drawing was number coded, and the number of "hits" under each number code was totaled. New brake shoes were not counted since there was no indication of how the shoes would wear. In most cases, the brake shoes were observed from both sides of the car, but this was not always possible since the data collectors were discouraged from crossing over between cars. Once the data was collected, it was broken down into various categories such as truck capacity and brake rigging type.

BODY-MOUNTED RIGGING TYPES

The types and sample sizes of body-mounted rigging examined were bottom rod-through (1,262 shoes), bottom rod-under (408 shoes), and hook-and-eye (508 shoes) configurations. As can be seen in Exhibit 1, the results for hook-and-eye and bottom rod-under are virtually identical, and both show more even brake shoe wear than rod-through rigging.

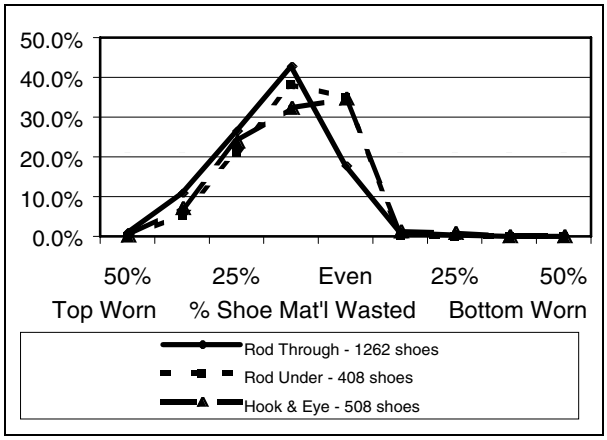

Exhibit 1. Comparison of Body-mounted Rigging Types

The type of body-mounted rigging usually dictates whether the dead lever is anchored to the car body or the truck bolster. Table 1 shows the percentage of cars with each type of brake rigging with truck-bolster anchored dead levers.

Table 1. Taper Shoe Wear versus Dead Lever Anchor

Rigging Type	Percent of Dead Levers Anchored to Truck Bolster	Percent of Brake Shoes with Top Wear
Rod Through (101 cars)	91.1	81.9
Rod Under (38 cars)	7.9	64.0
Hook-and-eye (74 cars)	0	63.4

Rod-through rigging typically requires the dead lever to be anchored to the truck bolster. The data indicates that the dead lever anchor location should be on the car body. Therefore, rod-through rigging should be avoided if possible as it generally requires a dead lever connection to the truck. There are other reasons to avoid rod-through rigging besides excessive tapered brake shoe wear, such as excessive side thrust on the brake beams, which can cause brake head contact with the wheel flange, and uneven brake shoe force on a given brake beam.[1]

TRUCK-MOUNTED RIGGING TYPES

The truck-mounted rigging types were split into two basic designs: direct acting and indirect acting. Direct acting TMB incorporates the brake cylinder into the brake beam, while indirect-acting mounts the brake cylinder on the truck bolster and actuates standard brake beams through a horizontal lever mounted on the truck bolster. Thus, all indirect acting designs are essentially

the same as three-lever, rod-through, body-mounted rigging. Exhibit 2 compares the TMB rigging types (designated as Types A and B) currently available with the old Wabcopac/Nycopac types, which are no longer in production.

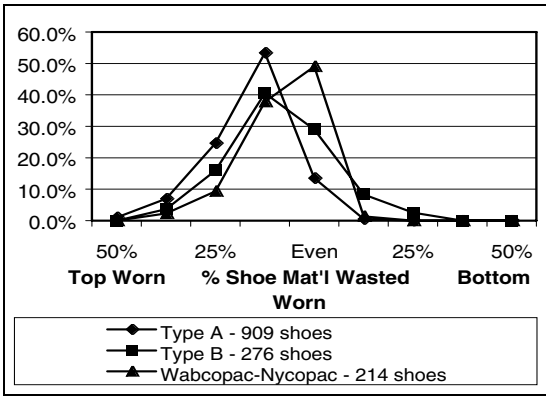

Exhibit 2. Comparison of TMB Rigging Types

Data indicates that the indirect and direct acting types that are currently available are inferior to the out-of-production Wabcopac/Nycopac types with regard to shoe wear. However, the new TMB types are superior to the old Wabcopac/Nycopac in many other ways. There is a difference between the indirect and the currently available direct acting types, but the types (A and B) will not be identified in this paper. Table 2 summarizes the data.

Table 2. Direct Acting TMB Comparison

	Percentage Top Worn
Type A	75.1
Type B	60.1

RIGGING AGE COMPARISON

When the data was sorted by decade of car built date (Table 3), the results showed that even new cars exhibit taper shoe wear -- again with more wear at the top of the shoe.

Table 3. Age Comparison of Rigging

Car Build Date	Percent of High-Mileage TOFC/COFC Cars in Survey	Percent of Top Worn	Percent of Worn Even
After 1995	43.4	66.7	32.6
1986-1995	60.3	84.6	14.9
1976-1985	20.0	69.1	29.2
Before 1976	11.9	75.3	24.0

The taper wear on the brake shoes continues to increase as the shape of the brake beam end extensions deteriorate with age. Note that the 1986-1995 data shows a sharp increase in taper wear. This could be due to the high percentage of these cars operating in high mileage, intermodal service resulting in an accelerated wear rate. This data suggests that the geometry of the unit guide is wrong, and that wear in the brake beam end extensions is a factor in allowing the nose of the beams to droop after some years in service. Since there is no procedure in place to condemn brake beam end extension wear, beams continue in service, theoretically forever, or until they are condemned for other reasons. One possible solution could be to condemn a brake beam if the shoe taper exceeds a specified limit

BRAKE BEAM TWIST

The taper shoe wear was compared on those brake beams where data existed for both brake shoes on the same beam. There were 1,010 beams in the survey with worn shoes on both brake heads. This number is less than the total of 3,909 beams since not all of the cars were inspected on both sides, and some brake shoes were new. Table 4 gives the results.

Table 4. Percentage of Twisted Brake Beams

	Difference in Taper Wear at Top of Shoe				
	z	0.5 in.	1 in.	1.5 in.	2 in.
Number of Brake Beams	458	404	100	11	1
Percentage of Total	45.3	43.6	9.9	1.1	0.1

Note that nearly 10 percent of the brake beams where taper shoe wear could be determined were twisted such that the difference at the top of the shoe was about 1 inch. This means that about 25 percent more shoe material is wasted on one of the two shoes. In addition, a twisted beam will tend to bind up in the end extension side frame pockets until a new shoe wears in, and even then may continue to bind. This can cause a loss in brake force on one or both ends of the twisted beam.

A twisted beam with a 1-inch difference in top wear will use about 15 more brake shoes for every 181,000 miles assuming that two 1 1/2-inch brake shoes will wear out on one side of such a twisted beam for every single shoe on the other head, and:

- 0.125 inch of shoe wear per 1,000 miles.
- $192.91 parts and labor for one new Number 24 brake beam.
- $13.30 for one 1 1/2-inch brake shoe replaced.

Thus, if such a beam were removed from service for excessive twist, the cost would be justified in about 181,000 miles of service.

There is currently no procedure in the AAR *Field Manual of Interchange Rules* to condemn twisted brake beams. Perhaps a measurement can be made of the tops of the brake shoes on the same beam when a wheel is removed from a truck for other reasons. If the difference in taper wear exceeds 1 inch, then the beam could be replaced at car owner's expense.

TRUCK MANUFACTURER AND CAPACITY

The data for truck manufacturer and capacity didn't show any significant differences with the exception of 125-ton trucks. The percentage of brake shoes worn in an even condition was less than that for 100-ton and 70-ton trucks. The different brake beam guide slot angle of 18 degrees for 125-ton trucks versus 14 degrees for the other trucks could be the cause. Table 5 lists the differences.

Table 5. Truck Manufacturer and Capacity

	Sample Size	Type of Wear	
		Percent Top Worn	Percent Worn Even
125-ton Trucks	227	87.7	11.9
100-ton Trucks	965	84.7	14.3
70-ton Trucks	918	83.8	15.7
Truck Brand A	661	83.7	15.9
Truck Brand B	677	77.8	20.7
Truck Brand C	157	81.5	17.8

CONCLUSION

This study shows that the brake beam interface with the truck needs to be addressed by the railroad industry. Taper wear is present even on new cars due to the fit of the side frame brake beam pocket and the brake beam end extension. Wear at the interface of the brake beam end extensions and the truck side frame only exacerbates this condition. Also, as car and truck bolsters increase in size to accommodate heavier cars, the room available for brake rigging is reduced. This has led to widespread use of rod-through body-mounted rigging, which is the worst performing body-mounted rigging in service today.[1] Lastly, there is no provision in AAR rules to remove brake beams with excessively worn end extensions or twisted brake beams. The industry should consider developing condemning criteria to remove these worn and twisted brake beams from service.

Future work under the Advanced Brake Rigging study will include tracking the performance of prototype rigging systems developed under this program in revenue service and at the Transportation Technology Center's Facility for Accelerated Service Testing; and monitoring the degradation of rigging efficiency on a group of cars that have been tracked since they were built. Both will projects will be discussed in future issues of *Technology Digest*.

REFERENCES

1. Carlson, F. "An Analysis of Commonly Used Body Mounted Brake and Truck Mounted Rigging," 91st Air Brake Association Convention, Chicago, Illinois.

Note: Please contact Fred Carlson (719) 584-0718 with questions or comments about this document.
E-mail: fred_carlson@ttci.aar.com
Web site: www.ttci.aar.com