

DYNAMOMETER TESTS OF A DISC BRAKE SYSTEM FOR FREIGHT CAR APPLICATION

by

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Summary

Off-tread braking will improve the productivity of rail freight transportation by allowing faster speeds on grades and in signal block territories. The AAR dynamometer was used to test a cheek-disc/caliper brake system that has promise for North American freight car application. The results of the tests with the combined tread and cheek-disc brake indicated that grade braking horsepowers can be doubled and stop distances can be halved when compared with the best obtained with the tread only brake.

The tests consisted of conducting constant force, constant speed, grade tests and stop tests with the disc only, with the disc and tread combined at various ratios of force, and with the disc and tread combined at higher disc brake forces.

The results of grade tests showed that the disc brake exhibited no heat fade and was capable of producing minimum retarding forces as high as 1100 pounds. In contrast, previous studies of tread braking showed that 550 pounds was the highest minimum retarding force attained with a 38-inch-diameter wheel because of severe fade at higher brake forces.

The results of the stop tests showed that the disc only brake produced shorter stop distances from 80 mph than the tread only brake when the distances were nearly the same for the two systems for stops from lower speeds. Moreover, the disc/tread brake produced substantially shorter stop distances than the tread brake when the disc brake force was increased.

The use of this disc brake system on North American freight cars depends upon several important factors. These are adaptability to the three piece truck, adaptability to curved plate wheels or acceptability of flat-plate wheels, and cost.



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INTRODUCTION AND CONCLUSIONS

To enhance productivity of rail freight transportation through increased speed, braking must be improved. Accordingly, some form of off-tread braking is needed to allow faster speeds on grades and in signal block territories.

The AAR dynamometer was used to test a cheek-disc/caliper brake system that has promise for North American freight car application. The components, purchased from SAB-WABCO (Bromborough) Ltd., are used in Europe for freight service. The brake pads were a UIC design and were made by Ferodo.

The tests consisted of conducting constant force, constant speed grade and stop tests with the disc only, with the disc and tread combined at various ratios of force, and with the disc and tread combined at higher disc brake forces. The combined system was studied because some tread braking is believed to be needed to maintain good wheel/rail adhesion characteristics.

The results of grade tests showed that the disc brake exhibited no heat fade and was capable of producing minimum retarding forces as high as 1100 pounds. In contrast, previous studies of tread only braking showed that 550 pounds was the highest minimum retarding force attained with a 38-inch-diameter wheel. This was because of severe fade at higher brake forces.

The results of the stop tests showed that the disc only brake produced shorter stop distances from 80 mph than the tread only brake when the distances were nearly the same for the two systems for stops from lower speeds. Moreover, the disc brake produced substantially shorter stop distances than the tread brake when the disc brake force was increased.

The results of the tests with the combined tread and disc systems indicated that the grade braking horsepower can be doubled and the stop distances can be halved relative to those of the tread only brake.

An AAR-S-660 finite element analysis of the flat-plate wheel used with this system showed lower stresses than those of curved-plate 38-inch wheels when the same grade-braking horsepower was used as the input.

The use of this disc brake system on North American freight cars depends upon several important factors. These are adaptability to the three piece truck, suitability for curved plate wheels or acceptability of flat-plate wheels, and cost. All of these factors are being addressed.

DYNAMOMETER TESTS

The cheek-disc/caliper system purchased from SAB-WABCO (Bromborough) Ltd. is shown in Exhibit 1. It features two braking discs, positioned on either side of the European-style 952.5 mm (37.5 in) diameter two-wear flat-plate wheel, fastened with four bolts through the wheel plate. The effective radius of the disc is 11.65 inches.

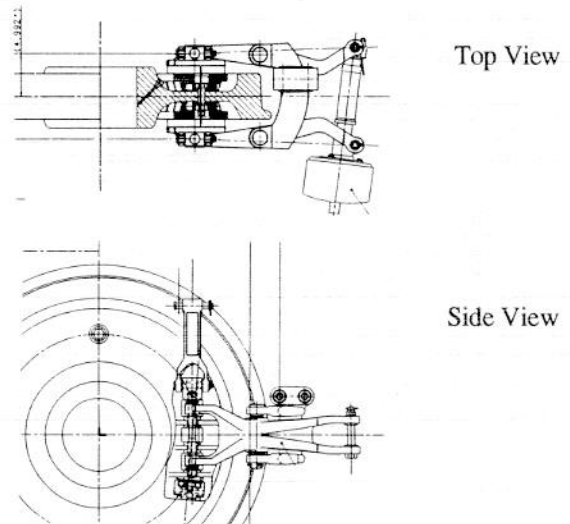


Exhibit 1. SAB-WABCO (Bromborough) Disc Brake System for Freight Service.

The brake pads are a UIC design with two pads per disc surface. The pads were manufactured by Ferodo and were deemed by SAB-WABCO to be the type most suitable for North American service conditions.

The cylinder diameter is 7.74 inches and the lever ratio is 1.46:1. Thus, at a brake cylinder pressure of 93 psi (emergency with a brake pipe pressure of 110 psi), a clamping force of about 6,400 pounds can be applied to the pads.

The AAR dynamometer was modified for the tests so



that the disc and tread brakes could be operated independently and in combination. Both brakes were operated in constant force mode with a controlled force buildup time of 5 seconds. Because our 38-inch-diameter wheels are normally used on 125-ton-capacity cars, the inertia discs were selected to produce an equivalent wheel load of 39,375 pounds.

Three types of tests were conducted: constant force grade (constant speeds of 20 and 40 mph); stops from speeds of 80, 60, 40, and 20 mph; and static. The tests were conducted in three stages. In the first stage, only the disc brake was used to ascertain the characteristics of the disc brake. In the second stage, both the disc and tread brake were used at equivalent disc/tread ratios of 1/1, 2/1, 3/1, and 4/1. The forces for these ratios were based upon equivalent retarding forces and stopping distances (from 60 mph) when either the disc or tread brake was used alone. For example, disc or tread brake forces of 4000 or 7250 pounds, respectively, resulted in a stop distance of 2600 ft. from 60 mph. Thus, a disc/tread ratio of 2/1 is about 2680 lbs disc/2392 lbs tread. In the third stage, the tread brake forces were set at the values for the 2/1 ratio, and the disc brake forces were increased in several steps.

RESULTS

Grade Braking

Previously, high-friction-composition brake shoes were tested with a 38-inch-diameter wheel on the AAR dynamometer. Exhibit 2 shows the results for grade braking at 20 mph for four force levels. The lowest force, 925 lbs, produced no fade. However, as the force was increased, the fade increased markedly. Increasing the brake force from 925 to 2750 pounds resulted in an increase of minimum retarding force from 400 to only 550 pounds.

The results of grade braking with the disc only brake at six levels of force at 20 mph are shown in Exhibit 3. The disc brake exhibits no fade. The retarding force does not decrease as the time of test (and disc temperature) increases. The retarding force generally increases with time. For reference, the relationship of horsepower to torque for 20 mph is 5.33 hp per 100 lbs retarding force.

These results show that the disc brake can produce

double the horsepower of the tread brake because of the absence of fade with the disc brake.

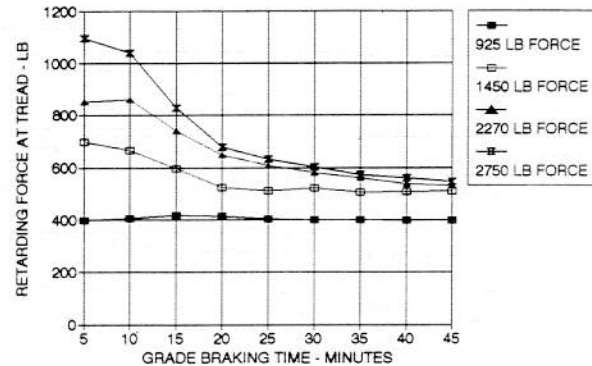


Exhibit 2. Grade Braking Performance of Tread Brake with CB-38 Wheel at 20 MPH.

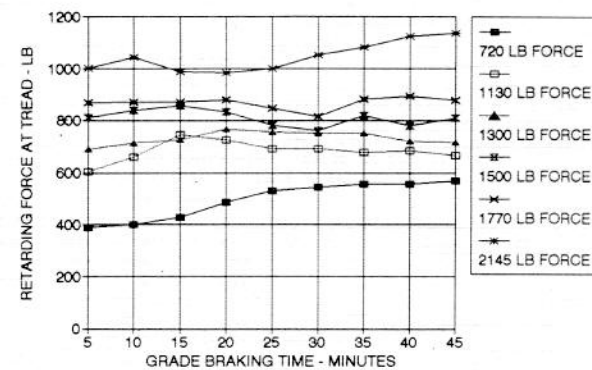


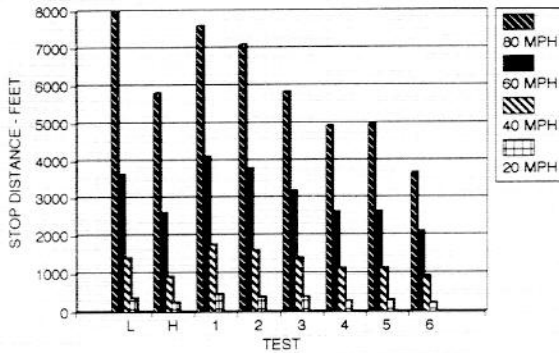
Exhibit 3. Grade Braking Performance of SAB-WABCO (Bromborough) Cheek-Disc Brake System at 20 MPH.

The results of grade braking with the combined disc and tread brake showed that the ratio of disc to tread force did not generally affect the results. Testing at 40 mph decreased retarding forces slightly but increased horsepower. Increasing the disc brake force with constant tread brake force increased the retarding force to high levels. The highest horsepower, 75 bhp, was attained with disc and tread brake forces of 757 and 478 lbs, respectively, at 40 mph.



Stop Braking

Exhibit 4 shows the results of the prior stop braking tests with the tread brake together with the results for the disc only brake. The tread brake forces, 3940 and 7250 lbs, were based on brake cylinder pressures of 50 and 93 psi, respectively, and a 10% brake ratio. Disc brake forces of 2600 and 4000 lbs produced stop distances similar to those for the tread brake for initial speeds of 60 mph or less. But shorter stop distances, by 900 feet, were produced from a speed of 80 mph. Increasing the disc brake force to higher levels decreased the stop distances further. A stop distance from 80 mph of 3600 feet was obtained with a disc brake force of 5655 lbs.



Test	Force-LB	
	Disc	Tread
L		3940
H		7250
1	2200	
2	2600	
3	3070	
4	4000	
5	4000	
6	5655	

Exhibit 4. Stop Braking Performance of Tread Brake and SAB-WABCO (Bromborough) Cheek-Disc Brake.

The results of stop braking with the combined disc and tread brake showed that the ratio of disc to tread force did not generally affect the results. As expected, increasing the disc brake force, while holding the tread brake constant, decreased stop distances. The shortest stop distance from 80 mph was 2900 feet. This was obtained with disc and tread forces of 6420 and 2392 lbs, respectively. Thus, the stop distance from 80 mph under emergency conditions can be reduced from 5800 feet with the tread brake force of 7250 lbs to as low as 2900 feet with the 6420/2392 lb disc/tread brake forces.

Static Tests

The results of limited static tests showed that the static coefficient of friction with the disc brake was 0.7. This was slightly higher than that for the tread brake, 0.6.

Wheel Stresses

A major concern is the stresses developed in the flat-plate wheel from tread braking. Therefore, an AAR-S-660 finite element analysis was conducted for the flat-plate wheel used with this system. The results showed lower stresses (maximum 65 ksi equivalent stress) than those of curved-plate wheels when 41.92 bhp (standard for 38 inch wheels) was used as the input. Moreover, in the combined system, lower horsepower would be put into the tread.

SUGGESTIONS FOR FUTURE WORK

The results of these studies show that this system has the ability to allow freight trains to operate at higher speeds. However, studies should be conducted to determine how a disc brake system, including other designs, can be adapted to a three piece truck. These include space, mounting arrangements, control arrangements, use of the cheek disc on curved plate wheels, alternate disc and caliper styles, and adaptation of the symmetrical flat plate wheel to AAR axles. Moreover, a study should be conducted to determine if the gains in productivity resulting from higher speed operation can offset the capital and maintenance costs of this system. Unfortunately, such studies appear at present to be beyond the scope of the AAR research program.

Note: Contact G. F. Carpenter (312) 808-5897 with questions or comments about this document.

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