

## The APL Wheel Slide Test by

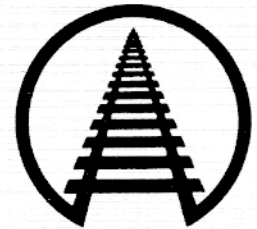
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TD94-005

### Summary

*Results of a recent AAR test indicate that the current industry practice of lubricating both the high and low rails to prevent double stack derailments may increase the incidence of wheel slide damage. Test results also indicate that the AAR maximum empty brake ratio of 30% is too high, and should be lowered to about 20%. A proposed revision of the AAR Specification, which would lower the maximum empty brake ratios from 30% to 25%, has been submitted to the appropriate AAR Committees for consideration.*

*This test has shown that wheel slide can occur on a 100-ton double stack car without any brake applications. It also showed that wheel slide can occur with light brake applications on an empty double stack car. All of the wheel slides occurred on lubricated track (both high and low rails) or when going over grade crossings. In one case, truck warp caused the brake shoe to be trapped between the wheel flange and the sideframe unit guide, resulting in undesired braking force which caused the wheel to slide on lubricated track.*

*The test was made on an American President Corporation double stack car, running empty from Omaha, Nebraska to Los Angeles, and loaded from Los Angeles to Chicago. The test car was operated in a revenue Union Pacific stack train. Test participants included Union Pacific Research Dept., Cardwell Westinghouse, ASF, Griffin Wheel, TTX, Thrall Car, Buffalo Brake Beam and AAR Research and Test.*



Association of American Railroads  
Research and Test Department

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## INTRODUCTION AND CONCLUSIONS

The AAR recently cooperated with American President Corporation and the Union Pacific to investigate why wheel slide damage was occurring on double stack equipment. The need for the investigation occurred when a 100-ton APC double stack was used to test the prototype WABCO ELX empty/load brake system. The test car developed wheel slides enroute to the test site. This occurred even though the empty/load system functioned as designed.

The study found that wheel slide can occur on an empty double stack, with light brake applications, on lubricated or possibly contaminated track. The study also recorded wheel slides on the empty and loaded car, without any brake applications, on lubricated or possibly contaminated track. In one case on the empty car, the wheel slide was due to truck warping, which trapped a brake shoe between the sideframe and the wheel flange. The wheel slid when it reached a flange lubricator. All of the flange lubricators which were factors in this test, lubricated both the high and low rails. The conclusions reached from this test are:

- While lubrication of both the high and low rails are desirable to prevent double stack derailments, the practice could increase the incidence of wheel damage.
- The available adhesion on well maintained mainline track can fall as low as 0.06.
- The present maximum AAR empty net brake ratio of 30% is too high for present service conditions, and should be lowered to at least 25%.

## INSTRUMENTATION

The instrumentation was designed to measure wheel speed and those factors thought to adversely affect wheel rotation. Truck warping was carefully measured in light of earlier experiences with wheel lock-up without any brake applications under a loaded Saint John River Power and Light coal gondola. Tight handbrake

rigging was also suspected as a possible cause, because the wheels "flat spotted" in the WABCO ELX test were the handbraked 4th and 6th axles. The car was tested empty to investigate light car wheel/rail adhesion during braking, and tested loaded to investigate possible brake beam binding due to truck warping.

Changes in truck geometry on trucks "C", "D" and "F" were measured with beam gages. These trucks were also instrumented for speed on both axles and live lever pin force. Four brake shoe force load cells recorded normal and retarding shoe force while moving. These were used on the "bad actor" axles 4 and 6. A load cell was installed in the hand brake rigging to determine if curving could possibly cause the handbrake rigging to tighten up. The three brake cylinder pressures and brake pipe pressure were also recorded.

These data channels, and the synthetic channels calculated from them, recorded the distance between the sideframe unit guides, the angle of each sideframe in relation to the bolster, the angle of the bolster in relation to the centersill, the vertical lean angle of each sideframe, and the spring height.

## TEST RESULTS

A number of wheel slip and slide events occurred during the empty and loaded trips. Most were discounted as false instrumentation triggers, but some genuine wheel slides did occur. All of the wheel decelerations on the loaded car occurred while the brakes were released. All of the wheel decelerations on the empty car occurred while the brakes were applied with the exception of one event, where the brakes were released. Some wheels on the empty car slowed from a train speed of 34 mph to less than 2 mph and stayed essentially locked up for about 15 to 25 seconds. Baseline conditions were recorded after the car had gone at least three miles on tangent track without grade crossings or special track work with the brakes released.



The worst acting wheel sets were axles 5 and 6 in the "D" truck and axles 9 and Z in the "F" truck. Prior to the test, the wheels on all intermediate trucks were replaced. They were worn in on a trip from Jacksonville, Florida, through Los Angeles and ending in Omaha, Nebraska. At the start of the test, the wheels in the "C" and "D" trucks already had non-condemnable flat spots entirely around the wheel tread. The wheels in the "F" truck were completely unmarked at the start of the test, but showed several non-condemnable slid flats when the car arrived in Chicago at the completion of the test.

**EMPTY CAR WHEEL SLIDES**

Five of the six slides on the empty car occurred with light brake applications. The wheel slides started when the car passed over a flange lubricator (both rails lubricated) in four of the six slides. One slide occurred on lubricated track and one slide occurred as the car was going over a grade crossing. In every case, there are indications that the available wheel/rail adhesion was as low as 0.06 when the slides occurred.

The worst slides occurred in one 13-minute slide event (termed Slide 7060) which contained four separate slides as shown in Exhibit 1. The train was descending a grade and negotiating a continuous series of 1° to 5° curves with a 10 psi brake application in effect. The weather was cold

with dew and frost on the ground. The first three slides occurred just as the wheels passed over a flange lubricator, and the last slide occurred entering a 5°50" curve 1.5 miles from the last lubricator.

One of the slides occurred without any brake application. The brake shoe load cells at the L6 wheel showed a retarding brake force of about 190 lbs., yet the normal shoe force was only 47 lbs with no force in the brake rigging. The truck was warped entering a 5° curve as shown in Exhibit 2.

The retarding force was present and constant on the wheel during the entire one minute slide event, but the wheel did not slide until the track lubricator was reached.

**LOADED CAR WHEEL SLIDES**

Two wheel slides occurred under the loaded car without any brake applications. In both cases, the car was going over a grade crossing on tangent track. The trucks in question were not warped, there was no evidence of wheel unloading, and the brake shoe load cells showed no retarding force on the #6 axle. At this point, the wheel slides under the loaded car are unexplainable, because brake shoe load cells were not installed on the axles which slid. Understanding this phenomena on the loaded car will require further testing.

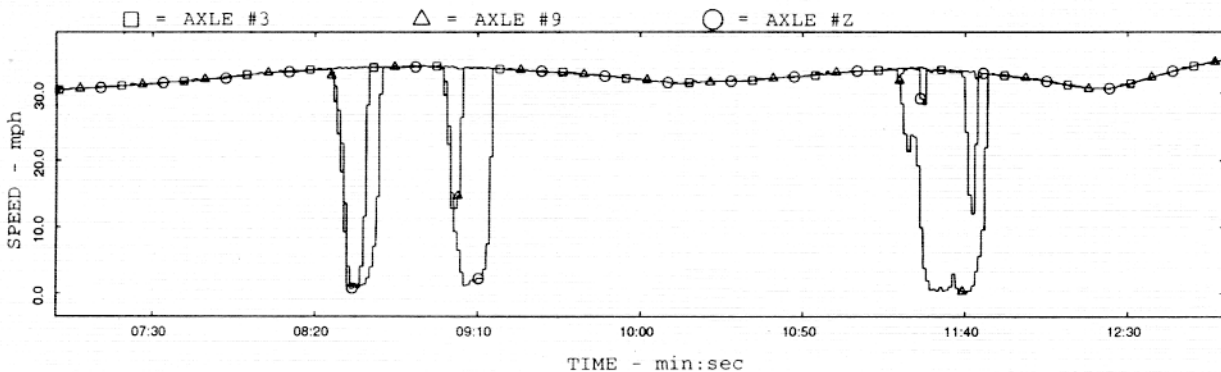


Exhibit 1. Slide 7060

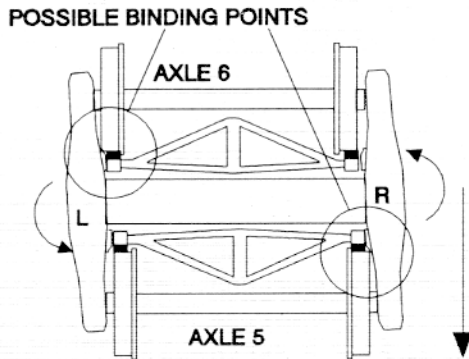


Exhibit 2. Truck warp during wheel slide without brake application. Car was moving in direction of large arrow.

**BRAKE SHOE FORCE TESTS**

The test car was given a brake shoe force test in Jacksonville, prior to the installation of the new intermediate truck wheels. The brake ratios of the empty car on a per axle basis was determined with a 20 psi reduction from a 90 psi brake pipe pressure. The brake cylinder pressures were 28, 32.5 and 31 psi for the "B", center, and "A" brake systems when a 20 psi reduction was made from a 90 psi brake pipe pressure. Table 1 lists the empty brake ratios, the adhesion demand for a full service application and the estimated adhesion demand for slide 7060 based on the actual forces recorded during the test. The estimated adhesion demand for each axle is based on the recorded brake cylinder pressures during the shoe force test, and during event 7060 and a brake shoe coefficient of friction of 0.35. It is interesting to note that the two axles which slid almost to a stop and slid the longest period of time (9 and Z), are the two axles with the highest empty full service adhesion demand of the instrumented axles.

The estimated adhesion demand for axles 9 and Z during the three worst slides of slide 7060 was only about 0.06, yet a common industry guideline has been that if the adhesion demand was kept below 0.12 the wheels would rarely suffer from flat spots. Research by Japanese National Railways (JNR) and British Rail (BR) have independently measured available rail adhesion on good mainline track as low as 0.05 (ASME 1992 RTD Vol.5, Pg. 101 and 102). The 0.05 available adhesion occurred in early morning rain on the JNR. From the results of the APC test, it appears that available adhesion can fall to about 0.06 at the rear of a 1.25 mile long train on a 40°F humid morning on some of the highest quality track in this country. This raises the distinct possibility that the current AAR maximum empty net brake ratio of 30% is too high, and should be lowered to about 20%.

Axle #	Empty Brake Ratio per Axle	Adhesion Demand	
		Full Service	Slide 7060
1	27.3%	.095	.078
2	25.8%	.090	.074
3	18.2%	.064	.052
4	22.1%	.077	.063
5	21.0%	.074	.052
6	21.7%	.076	.054
7	21.0%	.074	.052
8	22.8%	.080	.056
9	22.7%	.079	.059
Z	24.1%	.084	.062
Y	23.7%	.083	.061
X	24.0%	.084	.062

Note: Contact Fred G. Carlson (312) 808-5832 with questions or comments about this document.

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