TECHNOLOGY DIGEST

Timely Technology Transfer

Effect of Impact Loads on Vehicle and Track Structures

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TD 92-001

Summary

This Digest presents the results of a series of tests performed on track and equipment to assess the effects of various wheel tread irregularities, and to determine the extent to which the resulting impact loads are transmitted to car components and body structures. The tests show that freight car wheels with condemnable tread irregularities in the form of slid-flats, shells and spalls can cause excessive impact loads. These tests are part of a Research and Test program to establish economically viable guidelines for maximum acceptable tread defects. These guidelines will consider costs of damage to track and equipment.

The wheel impact load tests were run in August 1990 at the Transportation Test Center (TTC) Pueblo, Colorado with 70 and 100-ton cars instrumented to measure the roller bearing loads and axle and car body accelerations over tangent and curved track with instrumented track sections.

The test results indicate that the impact loads due to wheel tread defects are transmitted to truck components and car structure after some attenuation. The measured peak bearing adapter accelerations ranged from 50 to 125 g's, depending on the defect and track construction type. Although considerably attenuated, the high frequency components of the impact loads and accelerations were measured and quantified on the bolster and car body structures.

The highest loads and accelerations were measured on the cars with out-of-round and built-up tread type defects. The effect of wheel tread defects at the wheel/rail interface was much more pronounced: rail impact loads as high as 194,000 lbs were measured under the 100-ton car with an out-of-round wheel at 40 mph. The test results also showed that a newly surfaced track can experience substantial damage due to repeated hammering with wheel tread defects. Subsequent tests, conducted in 1991 addressed a wider range of tread anomalies. These will be reported as test data is analyzed.

Association of American Railroads
Research and Test Department

January 1992

INTRODUCTION AND CONCLUSIONS

As part of an effort to develop guidelines for maximum allowable sizes of wheel tread anomalies, AAR researchers reviewed the current industry experience with wheel impact detectors and wheel tread irregularities. The results of this survey clearly emphasized the need to develop information on the detrimental effects of impact loads to permit review and revision of the current wheel removal criteria.

Under AAR Rule 41 A, flat spots are limited to 2 inches in length for one slid spot and 1.5 inches for each adjoining spot. Similarly, shells and spalls are limited to 1 inch in length and width. The rule does not specify any load levels or speed of operation associated with the condemnable wheels, neither does it specify any limits on out-of-round wheels with long wave length defects.

Based on the results of the AAR survey, a set of technical objectives were identified to help enhance the understanding of the wheel tread anomalies and to quantify the economic and safety implications associated with wheel impact loads. This Digest presents the results from a recent series of tests conducted at the Transportation Test Center.

Analysis of test results has lead to the following conclusions:

1. Peak impact loads resulting from condemnable wheel defects ranged from 60,000 to 194,000 pounds on wood tie track.

2. Higher impact loads were measured under the 100-ton car than the 70-ton car. This dynamic augment due to impact was greater than would be expected solely due to the increased static axle load.

3. Train speed, defect type and shape, and track stiffness can have a significant effect on impact loads.

4. Impact loads are transmitted from:
- the wheel/rail interface to the bearing adapter and other truck components after substantial attenuation (peak bearing adapter loads in excess of twice the static load were measured);
- the axle with defective wheels to the axle with good wheels through the side frames (almost unattenuated);
- the sideframes to the truck bolster through the friction elements (the amplitudes of impact load on the truck bolster is negligible, but the high frequency content is retained);
- the truck bolster to the carbody (peak impact accelerations on car body (2 to 10 g's) attenuated by an order of magnitude from that measured at the axle level); and
- the end of the car with defective wheels to the other end with good wheels.

5. Wheel flats may be especially detrimental to wheel/axle/bearing assemblies due to high frequency, high amplitude impact vibrations transmitted from the wheel/rail interface.

6. As a result of impact forces, a wide range of track/vehicle resonant frequencies ranging from 20 to 500 Hz. are excited. The resulting vibrations may be more damaging to brackets and other fixtures attached to the car and possibly to the lading than the stiffer vehicle structure.

IMPACT EFFECTS DUE TO WHEEL TREAD ANOMALIES

All tests were conducted on tangent and curved track sections of wood and concrete ties at TTC. The first series of tests was run over a tangent section of track at speeds from 20 to 70 mph.

The track was instrumented with twenty load circuit bridges to measure the wheel loads in ten consecutive tie-cribs. Both onboard (truck bolster and bearing adapter loads, and axle and carbody vertical accelerations) and wayside data were collected for this series.

The second series was run over curved and tangent sections of track at speeds of 15, 20, 30, and 40 mph. Only the onboard data was collected in this series. The test zone included concrete and Azobe wood ties, as well as various frogs and turnouts.

Non-defective wheels and wheels with various types of service induced condemnable defects were installed under the leading axle of the leading truck of each car. These defects included slid flats, shells, out-of-rounds, and built-up-treads.

Tests conducted with the four different types of condemnable wheels produced rail loads ranging from 60,000 to 194,000 pounds. The highest loads and accelerations were measured under a loaded 100-ton car which had a combination of tread defects including an out-of-round shape with large divots and shells. The same 100-ton car produced severe impact loads up to 140,000 pounds with wheels condemned due to a combination of tread buildup and smaller flats. The peak impact loads measured under the 70-ton car with any defect type never exceeded 90,000 pounds. Analysis of the test data showed that the effect of impact on the adjacent load cribs and on the opposite rail was negligible.

Track surface measurements showed that a newly surfaced track can experience some ballast degradation and settlement due to repeated hammering from wheel tread defects.

The test results also indicate that the impact loads due to wheel tread defects are transmitted to truck components and to the car structure after some attenuation. Peak bearing adapter acceleration

Exhibit 1. A Photograph of the Test Consist (Locomotive, T7 Instrumentation Car, 70-ton Box Car and 100-ton Hopper Car).

due to impact ranged from 20 to 125 g's during impact. Exhibit 2 shows an example of the extent to which the wheel impact loads due to condemnable tread buildup (BUT) are transmitted to truck components and to the car structure.

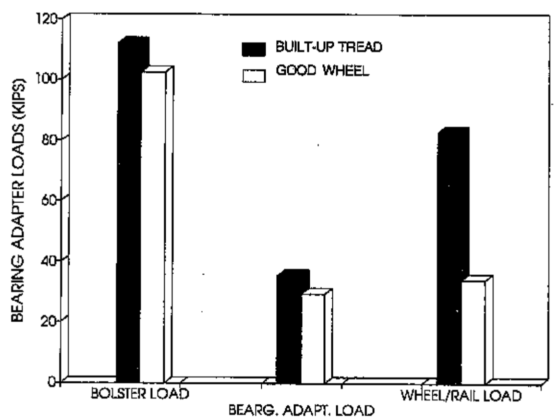

Exhibit 2. Transmission of Impact Loads into Bearing Adapter and Carbody, 70-ton Car, Built-up Tread.

The dynamic augment to static bearing adapter load varied from 10 to 100%, depending on speed and defect type. Contrary to expectations, the results also showed a high degree of interaxle bearing adapter impact load transmission from the wheelset with tread defects to the adjacent wheelset with good wheels. It is believed that the unattenuated transmission of the impact load to the adjacent axle with good wheels is due to pivoting of the side frames.

The bolster loads measured under the 70-ton car showed a strong presence of the wheel impact loads with high frequency content, although the peak loads resulting from impact were only about 10 percent above the bolster static load level. Peak acceleration levels measured on the leading end of the carbody were attenuated by an order of magnitude from that measured at the axle level.

The acceleration and load power spectra were computed to determine the higher frequency content of the vehicle response to impact loads. It was found that the power spectra at the truck and carbody acceleration levels contained identical peaks with substantial power accumulation in the 10 to 150 Hz range, with less pronounced peaks at frequencies up to 500 Hz.

The effect of track stiffness on the impact loads generated under the 70 ton and 100 ton cars was also evaluated. Exhibit 3 shows a comparison of the bearing adapter loads measured with good wheels with those with tread buildup at 30 mph. The peak bearing adapter acceleration of 125 g's was measured on tangent track with concrete ties (the corresponding bearing adapter load was about 67,000 pounds).

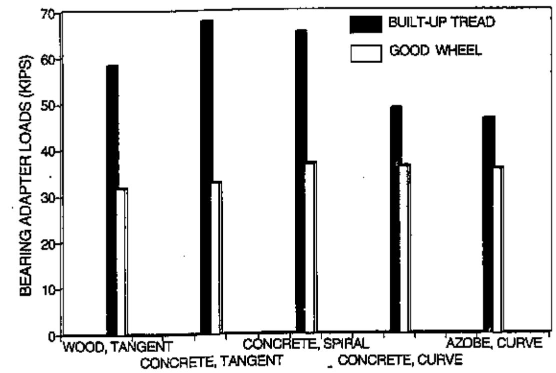

Exhibit 3. Effect of Track on Impact Loads. Right Bearing Adapter on 100-ton Car.

The effect of impact on curved track was less severe than on tangent track. This may be due to the fact that on curved track, peak impact load and accelerations can vary as the wheel tread moves laterally on the rail head toward flange contact. On tangent track, however, the wheel tread with the prominent defect feature will run on about the nominal "tape line."

Additional tests were run in 1991 to evaluate the effect of wheel flat size on impact loads. A recommendation as to allowable defect size will be proposed for consideration by the AAR Mechanical Division's Car Engineering Committee in 1992.

Note: Contact Semih F. Kalay at (312) 808-5842 with questions or comments about this document.

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