

Wheel/Rail Impact Loading

Increasing attention is being devoted to the dynamic interaction between wheel and rail and the corresponding impact loadings that can result from aberrations in either the wheel or rail surfaces. This interest has arisen from the growing awareness of the damage produced by greater wheel/rail loading, both *static*, because of heavier cars, and *dynamic*, due to such diverse factors as wheel and rail surface anomalies.

As a better understanding of the effects of increased loadings on the lives of both equipment and track components is achieved, more important becomes the monitoring and controlling of these loads. This is particularly true for "excessively" high dynamic wheel/rail loads. These loads, which are often related to defects in the surface of either the wheel or the rail, can be controlled by

proper maintenance of wheel and/or rail surface conditions. It is an area that has become the subject of active research in the last several years.

Wheel defects

Wheel surface defects and their consequences in terms of dynamic impact loadings have been receiving added attention, though the subject has been of interest since the 1950's. Back then, an Association of American Railroads joint committee examined the effects of wheel flats on track and equipment.¹ The study revealed that 2½-inch wheel flats can produce wheel/rail impact ratios of 2 and more. The wheel/rail impact ratio is defined to be the ratio of the dynamic wheel load to the static wheel load. Consequently, a ratio of 2 means that the dynamic

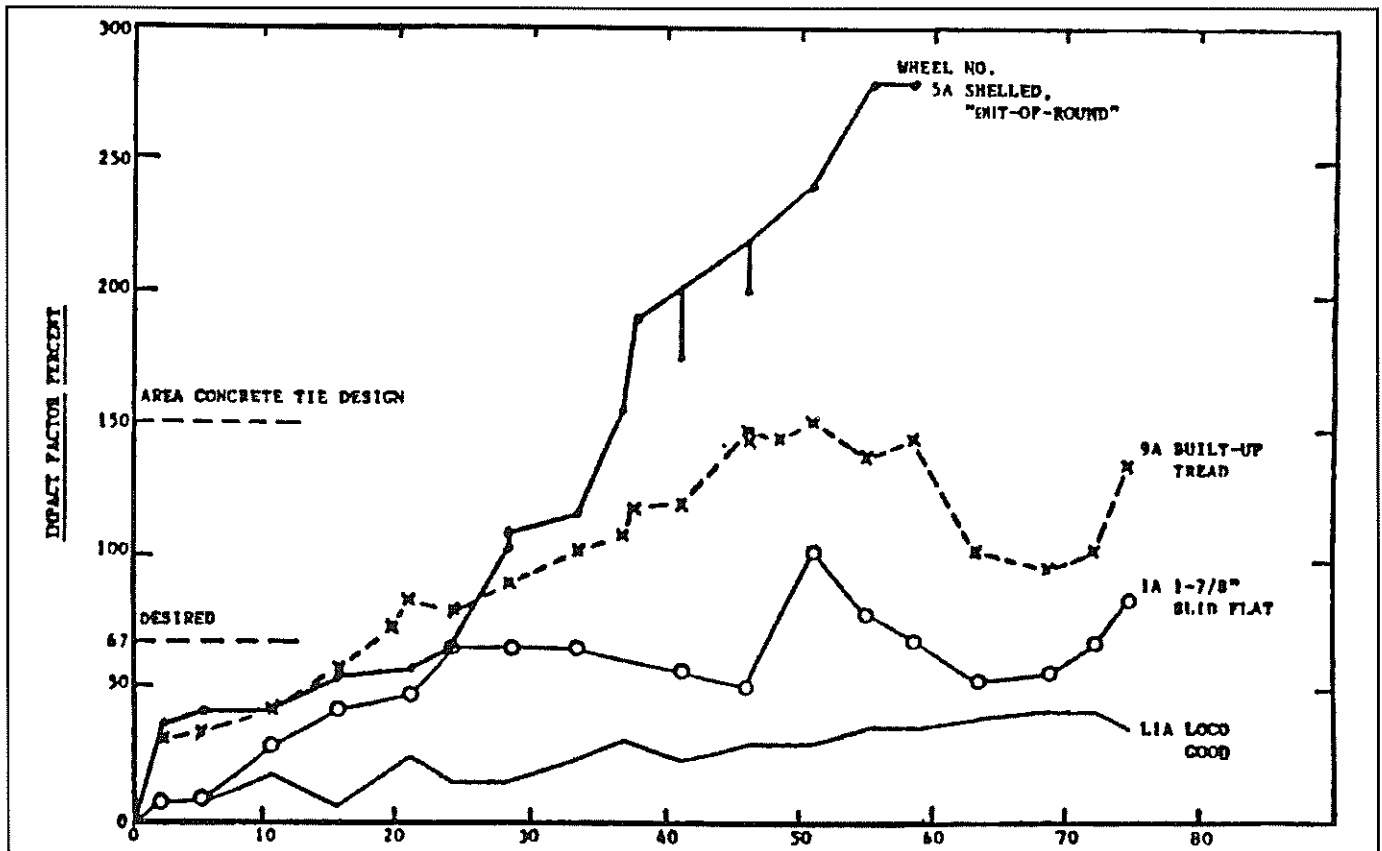


Figure 1 — Impact Factors on Load Wheels of 100 Ton Cars²

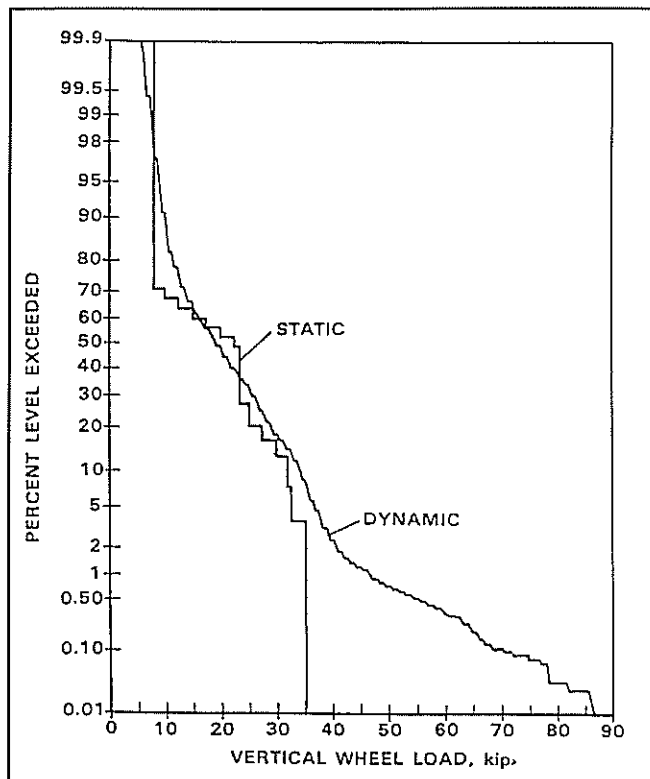


Figure 2 — Static vs. Dynamic Exceedance Curves¹

load is twice that of the static wheel/ratio load. Flat spots of $4\frac{1}{4}$ inches were found to give impact ratios greater than 4.0. As a result of these tests, it was recommended that a wheel with a flat spot having a depth greater than 0.050 inches, which corresponds to a wheel chord length of $2\frac{1}{2}$ inches, should be removed from service.

However, more recent research, prompted in part from an increasing use of concrete ties, has examined other wheel anomalies. These include out-of-round conditions and wheel shells. While these are “acceptable” under current AAR interchange rules, they appear to produce wheel/rail impact forces as great as or greater than those produced by condemnable flat spots.

Two recent studies, performed independently on two different railroads, have produced some interesting wheel/rail loading data. The investigations indicate that there are in general use wheels which produce extremely high vertical impact forces.

One of these studies, carried out on CN Rail,² examined wheel/rail impact forces on concrete tie sections on tangent track, bridges, and turnouts. In all cases, the

study reported measured wheel/rail impact factors over 150 percent, with some cases showing factors greater than 250 percent. At greater than 250 percent, the dynamic impact load is more than $3\frac{1}{2}$ times the static wheel load; and these for wheels that are classed as non-condemnable under current AAR interchange rules. Figure 1 presents one such set of data showing the impact factors generated by four selected wheels, all classed as non-condemnable, as a function of train speed. Two of these wheels exceeded the 150 percent impact factor value, which is established by the AREA as a design value for concrete cross-ties. One of these wheels, which was a shelled wheel having an “out-of-round” valley, generated a dynamic impact force of 124,000 lbs. This is 3.77 times the static wheel load, giving an impact factor of 277 percent.

Amtrak test

Similar results were obtained in concrete tie track on Amtrak.³ There, under both high-speed passenger and conventional freight operations on the Northeast Corridor, extremely high vertical wheel/rail forces were measured. As in the case of the CN, many of these high wheel/rail forces were obtained from wheel anomalies that were not condemnable under current interchange rules. Figure 2 presents a comparison of the distribution of static and dynamic vertical wheel loads, as measured at a test site on the Northeast Corridor. As in the case of the CN, it can be seen that the dynamic wheel/rail forces were found to be as high as $2\frac{1}{2}$ times the maximum static loads.

These results appear to indicate that under current North American operating conditions, there exists a small but significant population of wheels that generate excessively high vertical wheel/rail forces. In turn, they can result in increasing damage (and cost) to critical track components. Though the bulk of this research has concentrated on concrete tie track, it would appear that the same conditions exist for wood tie track as well, and with similar potential for increased maintenance costs.

References:

1. Association of American Railroads Joint Committee on Relation Between Track and Equipment, “Effect of Flat Wheels on Track and Equipment”, AAR Report MR-113, May 1951.
2. Scott, J. F., “Evaluation of Concrete Turnout and Bridge Ties”, AREA, Bulletin 706, Volume 87, May 1986. (Also see RT&S, August, 1986)
3. Tuten, J. M. and Harrison, H. D., “Design, Validation, and Application of a Monitoring Device for Measuring Dynamic Wheel/Rail Loads”, American Society of Mechanical Engineers, 84-WA/RT-10, 1984.