

Wheel Impact Load Detector Performance Tests Semih Kalay and Ali Tajaddini

TD 92-004

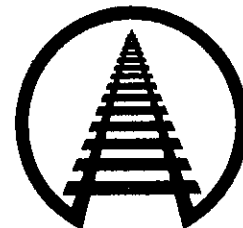
SUMMARY

Out-of-round wheels associated with long wavelength divots have produced very high impact loads ranging from 60,000 to 160,000 pounds in AAR tests. The tests were performed in August, 1991 at the Transportation Test Center in Pueblo, Colorado, to develop a statistical data base of the measured impact loads from a variety of wheel types.

Test results show that the impact load detector system evaluated during these tests clearly identifies high impact load producing wheels and is capable of distinguishing between defective and "good" wheels. However, the detector system occasionally underestimates the peak impact load if the prominent tread defect lands outside the influence zone of the rail strain gages. The variability in the impact load measurements increases with defect depth and speed. The results also show that a higher percentage of high impact producing out-of-round wheels are identified at load threshold levels set at 60,000 to 80,000 pounds. The optimum train speed at which the maximum detector coverage is achieved appears to be near 40 mph, for most defects.

The primary objective of these tests was to evaluate the performance of wayside wheel impact detector systems to measure and identify those wheels exceeding specified excessive levels of impact loads on track at typical freight speeds. Two radically different types of impact detectors; namely, a rail load and a rail acceleration measurement system were utilized in the test program. A total of 48 test wheel sets with various tread defects were installed under 70, 100, and 125 ton cars, and the resulting consist was operated over the detector site back and forth at various test speeds.

An alternative wheel removal criterion based on impact load detectors could be utilized to identify out-of-round wheels, as they are not covered under current AAR wheel removal criteria. It also seems possible from the data, that a statistically significant level of load threshold can be set using an impact detector to identify the wheels with tread defects only. The repeatability and speed sensitivity issues regarding a rail acceleration based system will be reported in future Technology Digests.



Association of American Railroads
Research and Test Department

February 1992



INTRODUCTION AND CONCLUSIONS

Recently the industry has begun to recognize the limitations of the current AAR Rule 41a criteria for condemning wheels due to wheel tread defects. Starting with wheel problems which were found on the Northeast Corridor's high speed passenger trains, it was discovered that Rule 41a permitted continued operation of certain types of wheel defects which could generate very high impact loads on the rail. Further work by the Canadian National showed that these high impact loads were not limited to high speed passenger trains, but could also be found in freight service. Since then, several railroads have installed wheel impact detectors which were developed from the work on the Northeast Corridor.

In 1989, AAR staff reviewed the current industry experience with wheel impact load detectors and wheel tread irregularities. The results of this survey published in AAR Report R-754 emphasized the urgent need to review current AAR wheel removal criteria. The survey data also showed that significant questions remained about the information obtained from the impact detectors. In particular, issues about speed sensitivity and repeatability of this type of measurement needed further research if impact detectors are to be used as supplementary tools for condemning wheels due to tread defects. A series of tests were performed to address these concerns and to develop a statistical data base of the measured impact loads from a variety of wheel types. The preliminary analysis of the test data using a load measuring impact detector supports the following conclusions:

- o The impact load detector system operated reliably during the full duration of the test program.*
- o The detector system clearly identifies the wheels with tread defects, although the repeatability of the measurement of impact loads is*

questionable for longer wavelength out-of-round wheels.

o The variability in the impact load was the highest for longer wavelength defects with large divots, especially at higher speeds. Further improvements may be needed in detection and processing of the peak impact load.

o Impact loads increase with an increase in depth of wheel defects and speed. The variability in the measurement of impact loads increases with defect size and speed.

o An optimum impact threshold level which will identify the out-of-round wheels (long wavelength defects with large divots) appears to be between 60,000 and 80,000 pounds.

o The percentage exceeding a specified excessive level of impact load threshold depends largely on defect size and speed. The optimum train speed at which the maximum detector coverage is achieved is near 40 mph for most defects.

o Excessive variation in peak load measurement at higher speeds can be due to the increased vertical dynamic activity at the wheel/rail interface resulting in loss of rail contact, and to the increased lateral motion altering the position of the wheel defect.

o The measured impact loads show a directional bias due possibly to the non-symmetrical shape of the defects.

IMPACT LOAD DETECTOR TESTS

Two different types of impact load detectors were utilized in this test program. The first system, a "typical" Wheel Impact Load Detector (WILD), was installed on concrete ties on the Transit Test Track at TTC. The system, which utilizes a series of strain gauges installed on the web of the rail, is the type used in the



majority of North American installations. Results from this system are reported herein.

A second impact detector system was also installed on the concrete tie track. The heart of this system is an array of accelerometers mounted on the rail base. This type of detector is utilized by several European railways. Results from this system will be reported in a future Technology Digest.

The wheels utilized in the test series included a number of condemnable and non-condemnable wheels, supplied by six major North American railroads. Defects present included slid flats, shells and spalls, out-of-rounds, and tread buildup. All test wheel sets were profiled for radial runout measurements before and after completion of the test series. The defective wheels were mounted under cars with axle loads ranging from 25 to 39 tons. A total of 48 test wheelsets were included in the program. A limited number of runs were made with empty cars, but the majority of the tests were run with fully loaded cars. The test consist (Exhibit 1) was operated past the detector site a minimum of 20 times in each direction, at each test speed. The test speeds ranged from 20 to 70 mph in 10 mph increments.



Exhibit 1. Test Consist Comprising 70-, 100- and 125-ton Cars used in Impact Detector Repeatability Tests.

Exhibit 2 shows repeatability of the peak impact load measured under a 36-inch diameter out-of-round (O.O.R.) wheel with a long wavelength defect, 20 inches in arc length and 140 millimeters in depth. This wheel set was originally identified at a revenue service detector, and the defects found were non-condemnable. It was also one of the most difficult wheels to measure, and represents the *worst case scenario*.

As seen in Exhibit 2, this wheel produced an average 125,000 pound impact load at a speed of 60 mph. The scatter found in the measured data was extremely large at higher speeds. In revenue service, the detector system is configured to measure the true peak only if the defect lands in the center of one of the ten instrumented tie cribs. Therefore, theoretically the detector system provides about 80 to 90 percent coverage for 36-inch diameter wheels. The lower impact readings may have resulted from a condition in which the impact had occurred off-center.

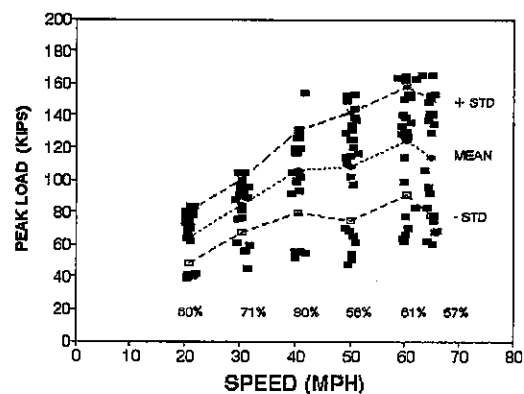


Exhibit 2. Impact Load Scatter Plot for the 36" Diameter O.O.R. Non-condemnable Wheel.

In Exhibit 3, the variability of this measurement is compared with that of the mating "good" wheel in terms of the mean value and standard deviation at each test speed. A close examination of the data reveals that the peak impact loads produced under the "good" wheel never exceed 50,000 pounds at speeds up to 50 mph.



In this speed range, the average impact load measured under the defective wheel remains above 70,000 pounds, indicating that the detector system successfully identifies the "bad" wheel. The mean value and standard deviation of the impact load increases with speed, even for the "good" wheel, due largely to increased vehicle dynamics.

One of the most frequently expressed concerns associated with the operation of impact detectors is the lack of guidelines for the setting of an impact threshold level which will identify AAR condemnable wheels only. Our test results are in close agreement with this experience in that selecting an optimum threshold load level, which will comply with current AAR wheel removal criteria, is almost impossible. Condemnable wheels do not always produce high impact loads, and many high impact wheels pass the current inspection criteria and are therefore non-condemnable. However, it seems to be feasible to detect high impact wheels, especially out-of-round wheels, using a detector system operating at an optimum load threshold level.

Exhibit 4 shows the percent coverage of impact loads exceeding a given threshold level at various speeds for the same wheel. The percentage of the measurements producing greater than 60,000 pound impact loads range from 83 to 100 percent at speeds above 20 mph. At the 80,000 pound load threshold level, the coverage ranges from 70 to 90 percent at speeds from 30 to 65 mph. Further analysis of the data is underway to determine the repeatability aspects of the detectors, based on various impact threshold levels.

CONCRETE TIE TRACK, 100-TON CAR WHEEL

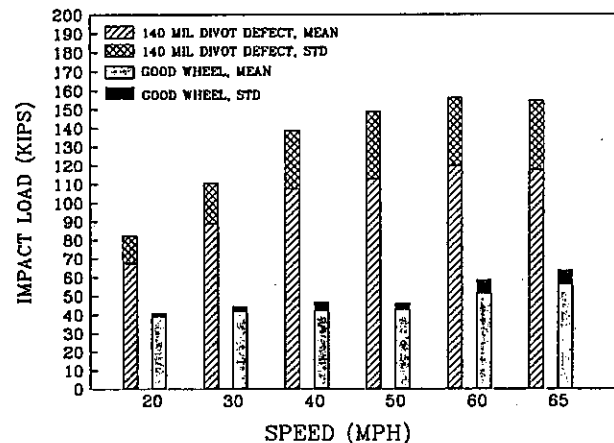


Exhibit 3. Comparison of Impact Load Statistics for Defective and "Good" Wheels, 100-ton Car.

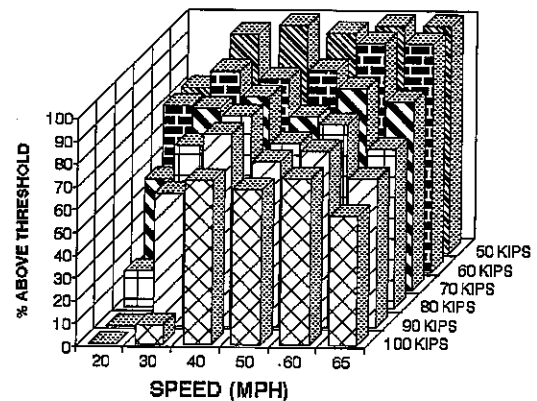


Exhibit 4. Impact Detector's Coverage of Wheel Impact Loads at Various Threshold Levels and Speeds, O.O.R Wheel.

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

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