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WILD Alerting on Empty Intermodal Carloads

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Key Findings:

- The vast majority of WILD peak force readings of 80 kips or greater occur on medium and heavy loaded equipment.
- Within a given six-month period, approximately 0.5 percent of cars that pass a WILD system are empty.
- A small number of cars are only measured empty, which creates an opportunity for better system coverage.
- With 90 percent probability, an alerting level of 76 peak kips on empty intermodal equipment for inner and outer trucks could be used to identify wheels that produce peak kip WILD readings of 80-89 kips within 30 days.
- With 90 percent probability, an alerting level of 88 peak kips on empty intermodal equipment for inner and outer trucks could be used to identify condemnable wheels that produce peak kip WILD readings of 90 kips or greater within 30 days.

TTCI has conducted an analysis to identify potential industry alerting levels for wheel impact forces produced by empty intermodal railcars. It is desirable to identify wheels in empty cars that have a strong possibility of exceeding Association of American Railroads (AAR) criteria once the cars are loaded. In 2019, 327 wheels were identified to meet this criteria. Identifying wheels with future potential to flag at detector sites allows car owners and handling railroads to conduct maintenance on a car before it is loaded with freight to be delivered to a customer.

The analysis included three categories of consists made up of cars with four or more axles; namely, "P" (conventional intermodal), "Q" (low profile or spine intermodal), and "S" (stacked intermodal). This work was performed under the direction of the AAR Strategic Research Initiatives program and in close coordination with the AAR's Equipment Health Monitoring Committee.

BACKGROUND

For roughly two decades, wayside Wheel Impact Load Detectors (WILDs) have been in railroad service in North America to identify high impact wheels caused by tread conditions. AAR criteria specify that a wheel can be removed once a WILD reading of at least 90,000 pounds (90 kips) peak force is reported. A wheel with a WILD reading of at least 80 kips peak force, but less than 90 kips peak force, also can be removed if the car is on a shop or repair track for any reason.1 In this Technology Digest, a wheel exceeding either of these criteria (at least 80 kips peak force) is deemed a high impact wheel (HIW).

Currently, there are 191 active WILD wayside systems in use. In the first half of 2020, the detectors identified 334,063 detector wheel passes between 80 and 89.99 peak kips, of which 96.5 percent were loaded, four-axle cars. For the same period, there were 147,656 detector wheel passes greater than or equal to 90 peak kips of which 97.4 percent were loaded cars.

Most WILD alerts occur with the car in the loaded condition; however, there are some cars that rarely cross a WILD system in a loaded condition. Unlike four-axle manifest and unit cars, intermodal equipment is not usually loaded to the rated gross rail load, but can be lighter depending on lading and operations.

This analysis included the following four subgroups:

- Empty: less than 25 percent load
- Lightly loaded: 25 to50 percent load
- Medium loaded: 50 to 75 percent load
- Heavy loaded: 75 to 100 percent load

Of the 60,723 unique intermodal cars that passed a WILD system in North America in the first half of 2020, 0.5 percent were always empty and 1.8 percent were lightly loaded while passing. This study examined the potential to use empty or partially loaded intermodal car dynamic WILD forces to identify wheels that would exceed current thresholds when the car is loaded.

A peak kip is 1,000 pounds of force on the rail by the wheel and is known to increase as a function of carload, wheel condition, and train speed.[2] Dynamic vertical forces are measured in kips and represent the additional forces generated by the tread condition of the wheel in excess of the weight of the wheel.

Dynamic ratio is a multiple of the weight of the wheel to the peak kips; dynamic ratio is always 1.0 or greater since the peak kips are not less than the wheel weight. Equations 1 and 2 define the dynamic vertical force and dynamic ratio, respectively:

$$Dynamic\ vertical\ force = Peak\ Kips - Wheel\ Weight$$

Equation 1. Dynamic vertical force equation

$$Dynamic\ ratio = \frac{Peak\ Kips}{Wheel\ Weight}$$

Equation 2. Dynamic ratio equation

ANALYSIS

The analysis was performed in four steps as follows to consider any differences by loaded car groups, truck position, wheel size, and the dynamic vertical force.

1. Determine intermodal truck empty or lightly loaded car groupings by percent load and truck position.
2. Determine intermodal truck grouping for each percent load group by wheel size.
3. Identify known HIWs and examine empty pass performance.
4. Determine probabilities of HIWs based on empty car WILD values.

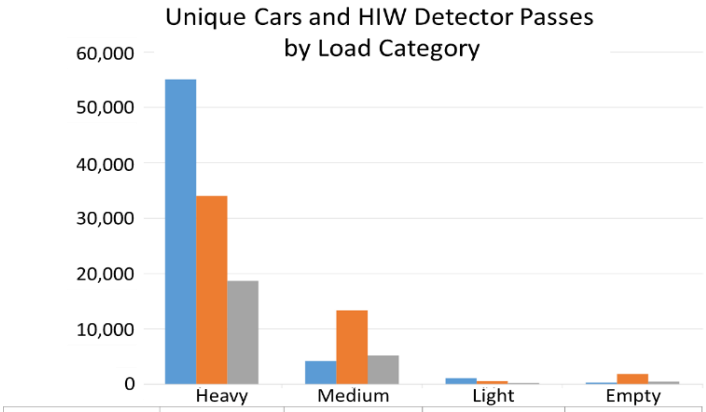
Performance of Known HIWs

To analyze the impact forces of different load categories and establish a methodology, wheels were identified that exceed AAR impact force criteria prior to and after the empty pass with the following conditions:

- Prior WILD pass of 90 to 99.99 peak kips.
- Within 14 days of the first pass, empty car pass with a train speed within 9 mph of the first pass.
- Within 14 days and 9 mph after the second pass, another 90 to 99.99 peak kips reading from a WILD pass

The same method above was used for 80- to 89.99-peak-kip wheels. Using WILD data from 2016 to 2019, a total of 963,195 unique wheelsets were identified and included in the analysis. The wheels were analyzed by percent load and wheel size groupings using dynamic vertical and dynamic ratios.

Figure 1 shows the unique cars and HIW detector passes by load category. From the figure it is observed that in the first half of 2020 most of intermodal cars were medium or heavy loaded. Also, detector passes of 80+ peak kips occurred on empty and lightly loaded cars.



	Heavy	Medium	Light	Empty
Cars	55,057	4,226	1,114	326
80 to 89 peak	34,015	13,351	566	1,871
90+ peak	18,683	5,214	240	504

Figure 1. HIW distribution

Truck Position and Percent Load Grouping

Each freight intermodal car has an empty weight of the car, as well as a maximum gross rail load. Cars were analyzed based on percent load groupings because heavier empty cars and heavier loaded cars can reach the alert levels with less additional force due to the wheel conditions.

This intermodal car grouping was created because it is common to see intermodal cars loaded to less than the rated gross rail load. In addition, a further grouping was conducted where each percent load subgroup was broken down by truck position as follows:

- Outer trucks: Trucks labeled "A" or "B."
- Inner trucks: Trucks labeled as "C" or any other denomination

Figure 2 shows histograms of dynamic vertical for inner and outer trucks in the empty car group. From the figure it is observed that inner trucks have a higher frequency of dynamic vertical values compared with the outer trucks. Similar behavior was observed for the remaining percent load subgroups.

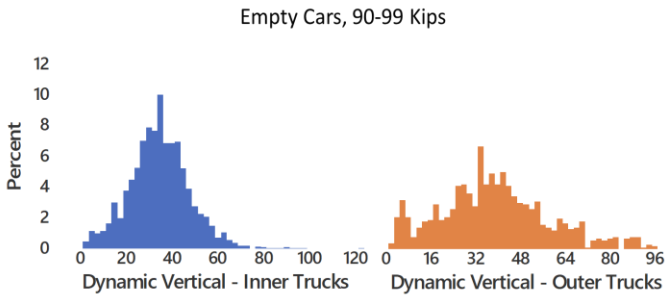


Figure 2. Dynamic vertical distribution for empty cars on inner and outer trucks

Truck Grouping by Wheel Size

In addition to the truck percent load and position grouping, an additional grouping was conducted to differentiate trucks with 33-, 36- and 38-inch nominal diameter wheels. Figures 3 and 4 present the empty car dynamic vertical histograms for inner and outer trucks by wheel size.

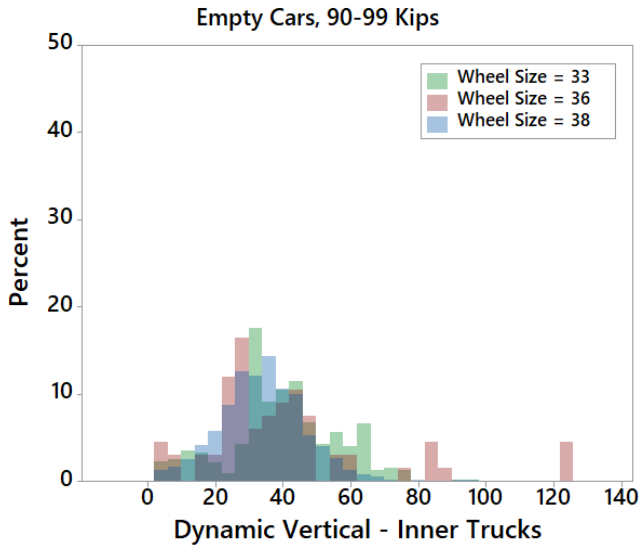


Figure 3. Distribution of dynamic vertical for empty cars by inner trucks and wheel size

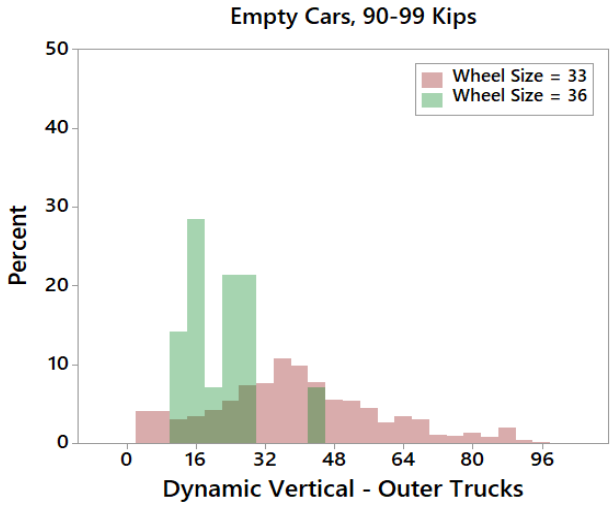


Figure 4. Distribution of dynamic vertical for empty cars by outer trucks and wheel size

The purpose of this grouping by wheel size was to identify the final truck grouping to conduct the probability analysis. From the figures it is observed that the histograms were overlapped for inner trucks in empty cars. In addition, most of the wheel sizes were 38 inches; this is because most cars have 38-inch wheels on inner trucks and 33-inch wheels on outer trucks. A similar pattern was observed for the remaining percent load groups. Since there was no separation between the different wheel size groups for inner trucks, there was no subgrouping. The same pattern was observed for outer trucks and for the remaining percent load groups; therefore, there was no further subgrouping for outer trucks.

Probability Analysis

Based on the resulting subgroups identified in the previous section, a separate analysis was conducted to determine the probability that a particular dynamic vertical force was recorded on a HIW when the car was in an empty, lightly loaded, or medium loaded condition. Figure 5 shows the likelihood of an empty car pass with a dynamic vertical (x-axis) and the probability the wheel is an HIW.

In the figure, the red oval indicates the dynamic vertical forces for each percent load and truck position group that are 90 percent likely to be an HIW within 30 days. The 90 percent likelihood that is noted in red is a non-statistical conservative value chosen as an example to provide high confidence of a wheel becoming an HIW for the next 30 days.

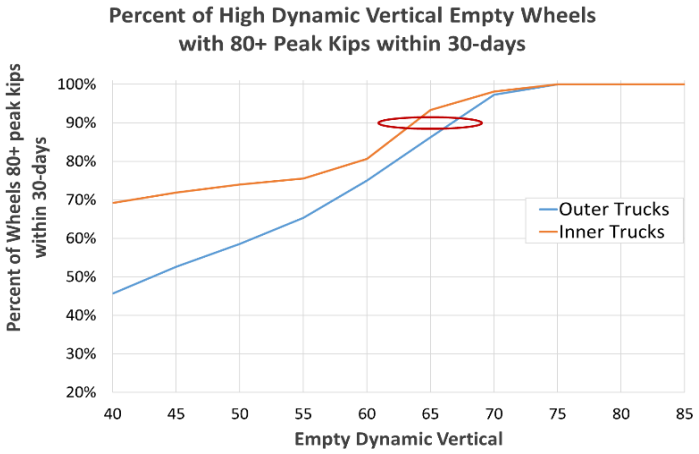


Figure 5. Probabilities for empty cars by inner and outer trucks and wheel size groups

The dynamic verticals range from about 63 to 68 kips for wheels with a 90 percent likelihood of recording an exceedance of AAR impact force criteria within 30 days. When adding each empty car's wheel weight to the values above, Table 1 shows the approximate peak kips (wheel weight plus dynamic vertical) that are expected for the empty car group.

Table 1. Estimated peak kips for the empty car group

Truck group	Wheel weight (kips)	Dynamic vertical at 90% (kips)	Estimated peak kips of empty car
Outer Trucks	8.97	67	75.97
Inner Trucks	12.15	63	75.15

Table 2 presents the peak kips summary at 90 precent likelihood for each percent load and truck position group. Adjusting for the average weight of the wheel for each load group, the equivalent peaks have less variance. For example, Row 1 for empty outer trucks would lower the condemnable at any time at 90 to 85.97 kips for empty intermodal cars. Likewise, in the same example, cars condemnable on repair track at 80 kips would be condemnable at 75.97 kips for empty intermodal.

Table 2. Summary peak kips at 90 percent likelihood

Car percent load group	Truck/wheel size group	80-peak-kip equivalent	90-peak-kip equivalent
Empty	Outer Trucks	75.97	85.97
Lightly Loaded	Outer Trucks	76.55	87.55
Medium Loaded	Outer Trucks	77.34	87.34
Empty	Inner Trucks	75.15	88.15
Lightly Loaded	Inner Trucks	75.16	86.16
Medium Loaded	Inner Trucks	74.11	87.11

Dynamic ratios (not shown) did not reach 90 percent likelihood of HIW for inner trucks and did not exceed on average 60 percent likelihood for outer trucks on 80+ peak kips. For 90+ peak kips, the inner trucks did not exceed 40 percent likelihood and inner trucks with 33-inch wheels and outer trucks did not exceed 60 percent likelihood. This analysis used dynamic ratio values up to 11.5.

CONCLUSIONS

- Current WILD alerting rules are enacted predominantly on medium and heavy loaded cars.
- A small number of cars are only measured empty, which creates an opportunity for better system coverage.
- With 90 percent probability, an alerting level of 76 peak kips on empty intermodal equipment for inner and outer trucks could be used to identify opportunistic wheels which would produce peak kip WILD readings of 80-89 kips within 30 days.
- With 90 percent probability, an alerting level of 88 peak kips on empty intermodal equipment for inner and outer trucks could be used to identify condemnable wheels which would produce peak kip WILD readings of 90 kips or greater within 30 days.

References

1. *Field Manual of the AAR Interchange Rules,* Rules 41.A.1.r and 41.A.2.e. 2020. Association of American Railroads, Washington, DC.
2. Kalay, Semih. May 1993. "Wheel Impact Load Detector Tests and Development of Wheel-Flat Specification." Research Report R-829, AAR/TTCI, Pueblo, Colorado.

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