REVIEW AND ANALYSIS OF WHEEL IMPACT LOAD DETECTOR (WILD) AND WHEEL REMOVAL DATA

Dennis Weed
Chief Mechanical Officer
Chicago Freight Car Leasing Company
Rosemont, IL

Cameron Lonsdale
Vice President - Technical
Standard Steel
Burnham, PA

ABSTRACT

Recent Association of American Railroad (AAR) rule changes have led to increased wheel removals and costs for private freight car fleet owners. Wayside impact load detector (WILD) systems now automatically flag high impact wheels in service for removal. This paper reviews the year 2003 wheel removal experience for Chicago Freight Car Leasing Company (CFCL) and compares that data to year 2003 wheel removals for the AAR Car Repair Billing (CRB) system. WILD data for CFCL are reviewed and discussed and strategies used by CFCL to deal with WILD trends are discussed. Wheel removal causes are also reviewed for selected Why Made Codes.

INTRODUCTION

CFCL's freight car fleet is made up of approximately 7,600 total cars, and consists of several different car types including covered hoppers, hoppers, bulkhead flat cars and gondolas. CFCL's fleet is in general freight service throughout North America and the average mileage for one of the cars is about 20,000 miles per year.

The AAR CRB database, which contains wheel removals for many car types and gross rail load (GRL) levels, can be used to analyze wheel failures and removal trends. However, this set of data is becoming less and less representative of the entire North American wheel population over time. With today's larger railroads more wheel repairs are done as system repairs, and more wheel repairs are performed at private car shops. These removals are not included in the CRB data. With a fleet of "general service" cars including flat cars and covered hoppers, CFCL's fleet should be more similar to the fleet represented by CRB data than a fleet of unit train coal gondolas, or articulated cars, for example.

The wheel removal analysis in this paper will follow the same general format as that used by Sullivan et al., for papers produced by the Railway Wheel Manufacturers' Engineering Committee (Ref. 1-4). Wheel removals were grouped by AAR Why Made Codes into four general categories as follows: Administrative, Wear Related, Environmental, and Wheel Failures. Also statistics will be used to compare the CFCL data to AAR CRB data.

2003 WHEEL REMOVAL DATA

AAR CRB (Ref. 5) and CFCL year 2003 wheel removal data are contained in Table 1. Note that only selected Why Made Codes are shown, and also note that data in this table are for individual wheels, not wheelsets. Figure 1 shows the data for 2003 wheelset removals by month. Removals did not necessarily take place in the month shown due to billing cycle delays. Note the “seasonality” trend of removals with an increase seen in the Spring after winter months when wheel/rail adhesion is lower and air brake problems are typically more common.

AAR Why Made Code	Category	AAR CRB	CFCL
7 Obsolete material	Administrative	654	2
11 Removed good condition	Administrative	236,102	1,562
23 Government Requirement	Administrative	816	34
25 Owner’s request	Administrative	912	24
90 Mate wheel scrapped	Administrative	48,205	155
65 High impact wheel – WILD	Environmental	33,011	202
67 Out-of-round - Gage	Environmental	10,230	70
74 Thermal crack	Environmental	3,926	45
75 Shelling	Environmental	62,689	380
76 Tread built-up	Environmental	7,655	68
78 Tread slid flat	Environmental	23,576	115
80 Scrape/dent/gouge	Environmental	3,887	33
60 Flange thin	Wear Related	18,952	93
64 Flange high	Wear Related	41,397	115
73 Rim thin	Wear Related	12,843	43
98 Not meeting reap. limit	Wear Related	4,226	28
66 Flange cracked/broken	Wheel Failure	171	4
68 Cracked rim	Wheel Failure	320	3
71 Shattered rim	Wheel Failure	143	0
72 Rim spread	Wheel Failure	100	3
Total all Why Made Codes (not only those listed)		**513,739**	**3,014**

Table 1. Year 2003 wheel removal data for AAR CRB and CFCL.

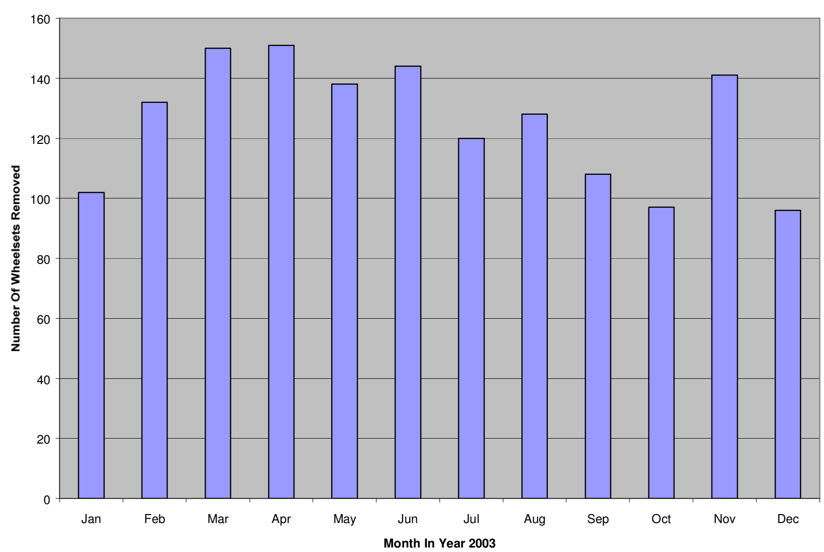

Figure 1. CFCL 2003 Wheelsets Changed Out.

The CFCL cars operate throughout North America on several different railroads and therefore are subject to repair at many locations. Figure 2 shows wheelset repairs by railroad while Figure 3 shows the miles that CFCL cars traveled on different railroads in

2003. Figures 2 and 3 show logical trending in that the number of wheel removals on a railroad decreases with a fewer number of miles traveled on that railroad. However, note that the “others” category in Figure 2 is a significant number – this category contains wheelset changeouts made at private car repair facilities. CFCL performs approximately 20% of wheelset changes at private shops to allow for proactive maintenance and to control costs.

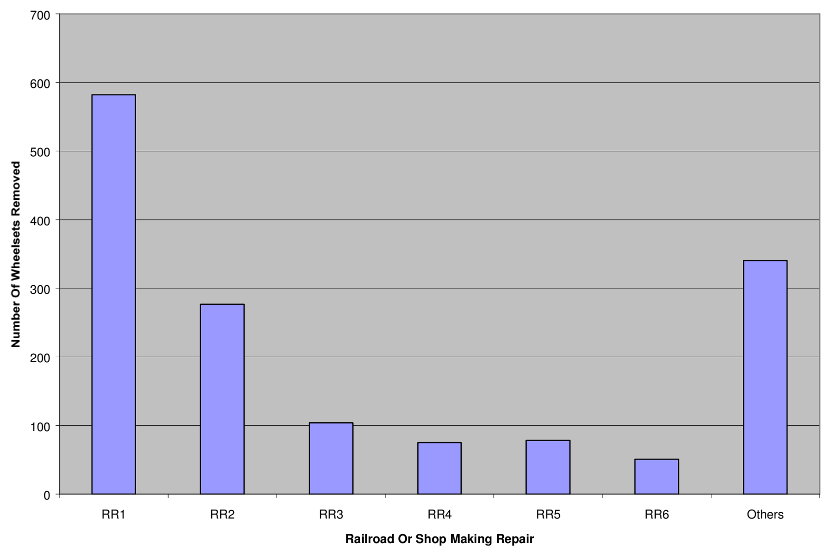

Figure 2. CFCL 2003 Wheelset Changeouts By Railroad/Shop.

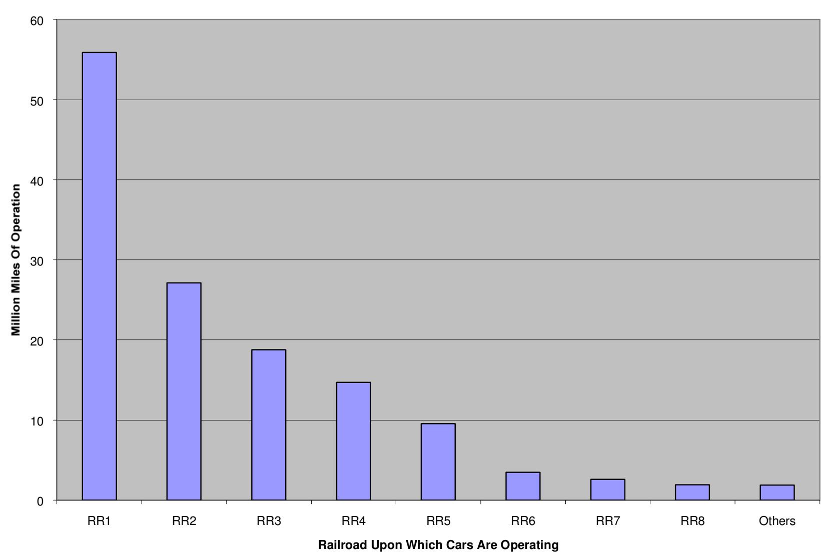

Figure 3. CFCL 2003 Miles By Railroad.

Figure 4 is a graph showing year 2003 CFCL wheel removals according to the category of wheelset removals. Note that Environmental causes are the top reason for CFCL wheelset removals – wheels are thus not wearing out as is desired by the car owner and resources are being wasted. Roller bearings are the second most frequent reason for wheelset removals. We note that CFCL does not account for Why Made Code 11 (removed good condition) in the "Administrative" category, rather the proper cause of the wheelset removal is recorded. As an example, if a wheelset is removed for reasons related to the roller bearings, the wheelset is not shown to be removed for Why Made Code 11.

Figure 5 shows the four year industry wheel removal trend (2000-2003) for Wear Related wheel removals. The graph shows the percent of wheels removed for the given Why Made Code. Note that the number of wheels removed for wear related causes has trended downwards due to the reduction in wheels changed out for high flange.

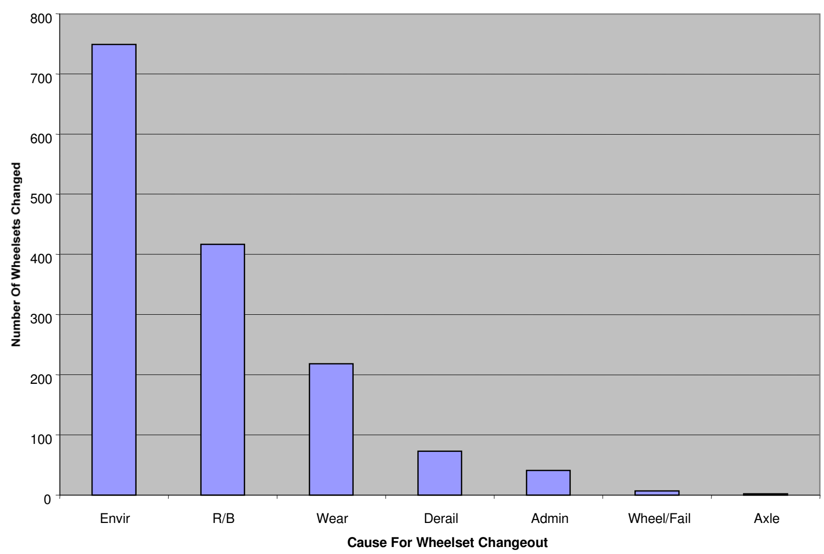

Figure 4. CFCL 2003 Changeout Groups.

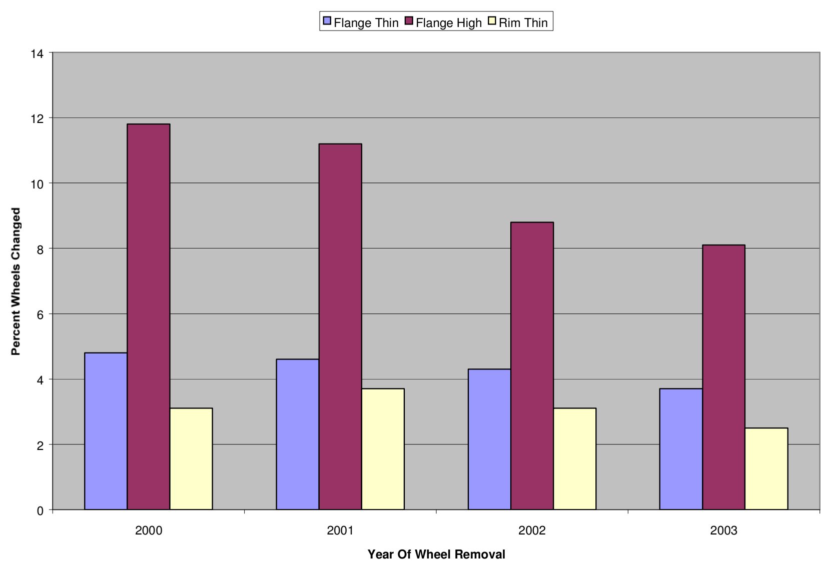

Figure 5. Four Year Wheel Removal Trend (Industry).

WHY MADE CODE 65 – HIGH IMPACT WHEEL, DETECTOR

Why Made Code 65 was established as of January 1, 2003 and applies for removal of wheels that have been identified by wheel impact load detector (WILD) systems. The development of the new removal code is part of an effort by North American railroads to reduce the "stress state" of the railroad. High impact wheels damage rails, car components, wheels, lading, etc., and are said to significantly increase track maintenance costs for railroads.

Wheel impact load in service must be 90,000 pounds or greater for wheels to be removed (Ref. 6). AAR rules also have established that the WILD detector must be calibrated per manufacturer's instructions, must reliably measure peak impacts and must provide printable records. Device calibration records also must be maintained. Wheels that have been slid flat by the handling line are not to be billed as out-of-round.

Until 2003, rules for out-of-round wheel (Why Made Code 67) removal were considerably different. Wheels were required to have a wayside impact load of 90,000 pounds and have been verified with an approved gage/measuring system to have a 0.070 inches out-of -round "runout" measurement. Currently, Why Made Code 67 (wheel out-of-round detected by gage) applies for wheels removed using the latter gage method.

For CFCL, 6.7% of wheel removals in 2003 were for the new Why Made Code 65. AAR CRB data shows that 6.4% of removals were for Why Made Code 65. However, more recent data (January 2004 through end of April 2004) shows that approximately 12.5% of CFCL wheel removals are due to Why Made Code 65. This suggests that perhaps CFCL's car fleet is somehow different than the AAR overall car fleet, or is experiencing different service conditions, since the percentage for high impact wheels is twice as high. Perhaps the higher percentage of Why Made Code 65 removals on CFCL cars is related to handbrake usage and wheel sliding in service.

SLIDING RELATED DEFECTS

Several Why Made Codes for wheel removals are associated with wheel sliding events in service. These include Why Made Codes 65, 67, 75, 76 and 78. It must be noted that Why Made Code 75 removals can be caused by two other service conditions – true shelling (rolling contact fatigue) and thermal-mechanical shelling (rolling contact fatigue with tread heating from drag braking). However, it has been generally accepted that most North American removals for Why Made Code 75 in general freight service are due to wheel sliding and subsequent martensite formation.

There are many papers in the literature that deal specifically with the causes of Why Made Code 75. Wheels with sliding related defects can eventually lead to high impact loads in service and removal under Why Made Code 65 or 67.

Wheel sliding can be caused by many factors, including, but not limited to, the following:

- Handbrake left on
- Air brake system problem
- Empty/load system not working properly
- Cars on rear of train pulled/not released
- Slippery rail
- Wheel/rail profile issue
- Train handling/braking
- Truck steering issues

Figure 6 shows AAR CRB data for wheel removals related to wheel sliding for the four-year period 2000 through 2003. For Figure 6, these causes include Why Made Codes 65, 75, 76 and 78. Note the large increase in removals during 2003 caused by the new Why Made Code 65 for high impact wheels.

Figure 7 shows the number of wheelsets changed out by month for the various removal categories as follows: 1) Why Made Code 65, 2) Other Environmental removals, and 3) Non-Environmental removals.

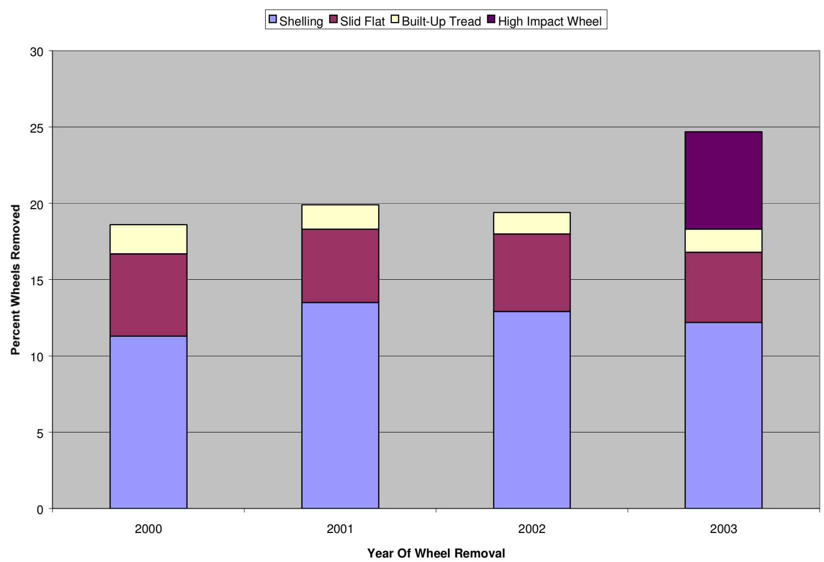

Figure 6. Four Year Sliding Wheel Defect Trend (Industry).

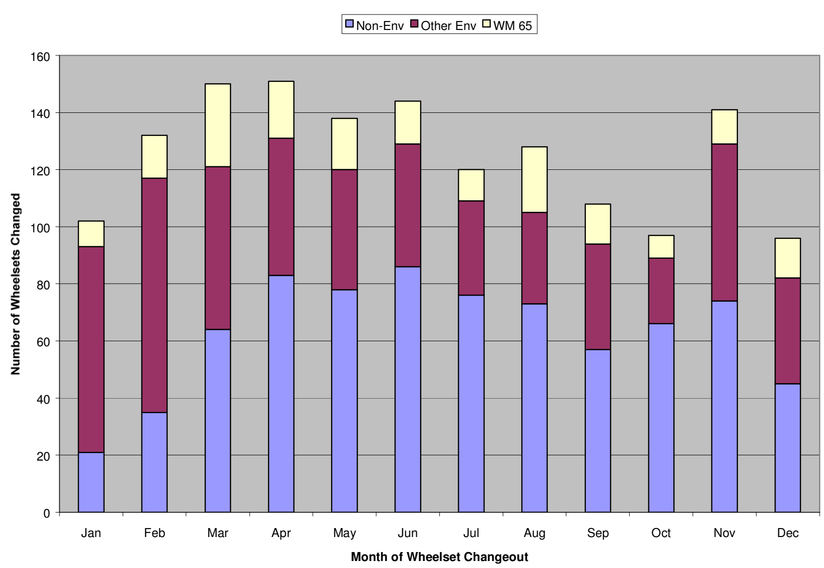

Figure 7. CFCL 2003 Wheel Sets Changed Out By Month.

CHI-SQUARE STATISTICAL COMPARISONS

The Chi-square statistical test can be used to compare two samples to determine if there is a statistically significant difference in performance between the two samples. In our case we desire to compare AAR CRB and CFCL wheel removals to see if there are similarities. The Chi-square test uses attribute data (i.e., "good" and "bad") for the comparison and the values in Table 2. For example, to compare wheel shelling, the 380 Why Made Code 75 removals for CFCL are considered as "bad" while the remaining 2,634 are considered "good" since they were not removed for Why Made Code 75. Minitab® statistical software is used for the Chi-square test. The software calculates a "P-value" and the expected number of values given the samples. If the P-value is less than 0.05, there is a statistically significant difference between the two samples. If the P-value is greater than 0.05, there is no difference in performance.

Comparisons for Why Made Codes 65, 67 and 75 showed no statistically significant difference in performance between AAR CRB and CFCL data. Comparisons for Why Made Codes 74, 76, 78 showed that there is indeed a statistically significant difference in performance between AAR CRB and CFCL data. For Why Made Codes 74 and 76, CFCL had more than expected removals, thus performance is considered to be worse than AAR CRB data. However, we note that CFCL had fewer than expected removals for slid flat wheels. A final comparison was made for wheel failures using grouped Why Made Codes 66, 68, 71, and 72. There was a statistically significant difference in performance between AAR CRB data and CFCL data, and CFCL had more wheel failures than the calculated expected number (10 actual vs. 4.3 expected).

The similarity in data between AAR CRB and CFCL is not surprising since the CFCL fleet is made up largely of general service cars, and the majority of CFCL wheelset repairs are made by railroads – thus are reported into the AAR CRB system. Data are summarized in Table 3.

AAR Why Made Code	CFCL or AAR	Actual Number of Removals	Expected Number of Removals	Statistically Significant Difference?
65, Impact detector	CFCL	202	194	No, P = 0.537
	AAR	33, 011	33,019	
67, Out-of-round	CFCL	70	60	No, P = 0.195
	AAR	10,230	10,240	
74, Thermal cracks	CFCL	45	23	Yes, P = 0
	AAR	3,926	3,948	
75, Shelling	CFCL	380	368	No, P = 0.498
	AAR	62,689	62,701	
76, Tread built-up	CFCL	68	45	Yes, P = 0.001
	AAR	7,655	7,678	
78, Slid flat	CFCL	115	138	Yes, P = 0.043
	AAR	23,576	23,553	
66, 68, 71, 72, Failures	CFCL	10	4.34	Yes, P = 0.006
	AAR	734	739	

Table 3. Chi-square comparisons, CFCL vs. AAR CRB.

SPEED/LOAD CORRECTION AND DEALING WITH WHEEL IMPACTS

There are several variables related to WILD detectors that could potentially lead to differences in load readings as wheels pass over them. These include, but are not limited to: 1) speed of train, 2) type of ties used, 3) stiffness and stability of subgrade, 4) type of sensor grid used, etc. As speeds increase the recorded load also increases. Thus a reading of 90,000 pounds at 60 mph is more likely than at 30 mph. AAR has been studying the issue of speed correction in recent years.

For 286,000 pound GRL cars, the typical wheel load should be 286,000/8, or 35,750 pounds. For 263,000 pound GRL cars, the typical wheel load is 32,875 pounds. CFCL uses a "rule of thumb value" of 34,000 pounds for all loaded cars, then adds 7,000 pounds for a total of 41 kips, which is a typical value for the majority of loaded CFCL wheels at about 56 mph in service. If a wheel has an impact load value of more than 41 kips this provides an indication that the wheel is trending in the wrong direction. If the impact load reaches 65 kips in service, a "yellow flag" is applied to the car record and a notification is sent to the car shop to have the wheel inspected.

Figure 10 is a photo showing the R3 wheel from car CRDX 13648 – the wheel was removed following a loaded impact reading of 75 kips in service. After the impact reading was detected, CFCL's car shop was notified to inspect and hold the wheel. Note the visible tread defects, clearly caused by wheel sliding. With rare exceptions (selected service cases where thermal mechanical shelling or true rolling contact fatigue are indeed taking place), wheel sliding causes general freight service wheel impacts.

Figure 10. R3 Wheel From CRDX 13648.

CFCL, like many other private fleet owners, uses data to help manage the wheel impact situation on cars. AAR/TTCI InteRISS data allows fleet owners to track the condition of cars and proactively manage high impact wheel changeouts. Figure 11 shows the distribution of all wheel loads for the CFCL fleet during a particular day in June 2004 while Figure 12 shows the same information for wheelsets. The majority of wheelsets are well below the condemnable limit of 90 kips and in fact the vast majority are less than 44 kips. Figure 12, which deals with wheelsets, is most relevant to CFCL from a management and cost control perspective. Although AAR CRB data for wheels are based upon individual wheels, CFCL sees the most value in using wheelsets. Repair costs are based upon exchange of the entire wheelset, even if only one wheel is removed for a particular defect.

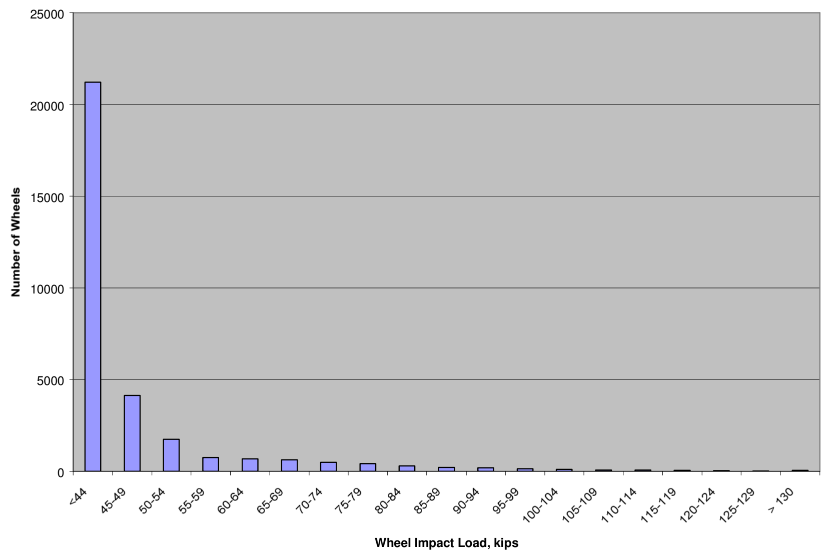

Figure 11. CFCL Fleet Kip Distribution For Wheels.

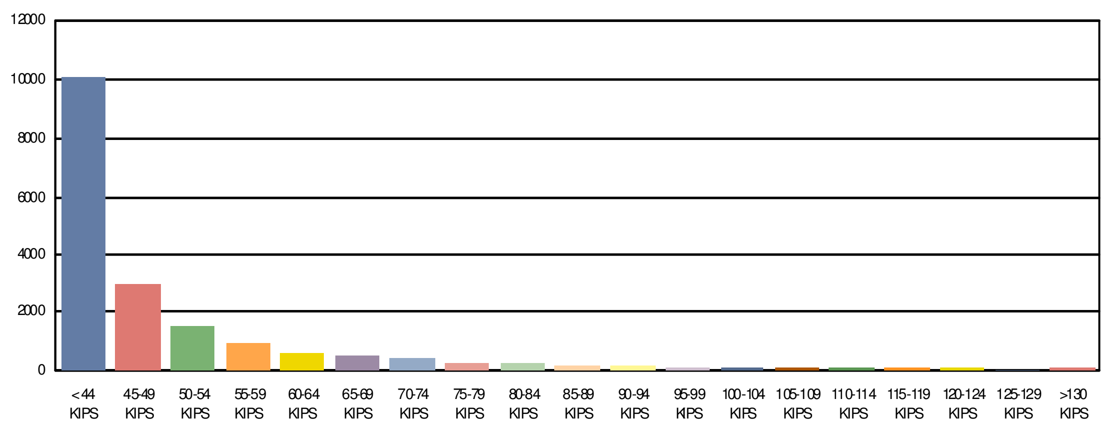

Figure 12. CFCL Wheelset Kip Distribution.

CFCL assigns a "flag type" to wheels with different wayside impact load detector kip values. A red flag is assigned to wheels with greater than 90 kips, a yellow flag to an impact range of 66-90 kips, and no flag to impact readings less than 65 kips. Figure 13, 14 and 15 show the impact load distribution for wheels with no flag, yellow flag and red flag, respectively for the same day in June 2004. Yellow flag wheels are scheduled for repair in advance of being repaired by railroads as this helps to control costs and prevent delays to loaded cars in service.

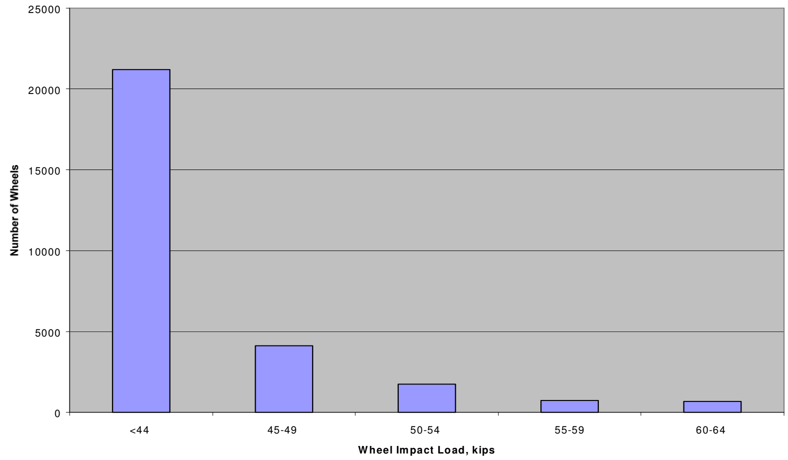

Figure 13. No Flag Wheel Impact Load Distribution.

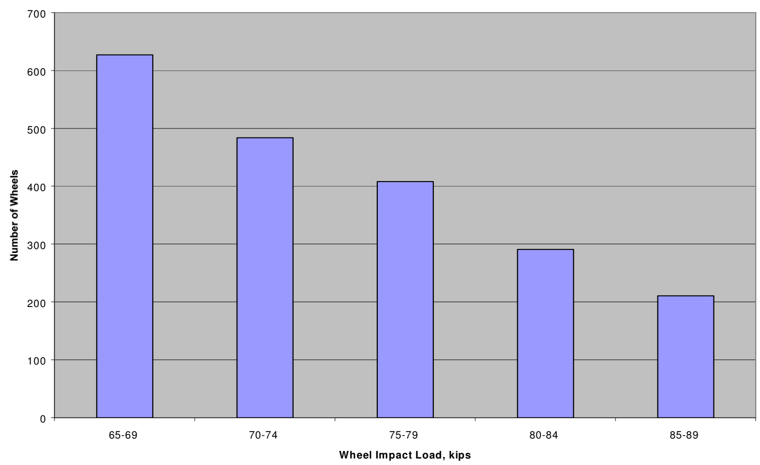

Figure 14. Yellow Flag Wheel Impact Load Distribution.

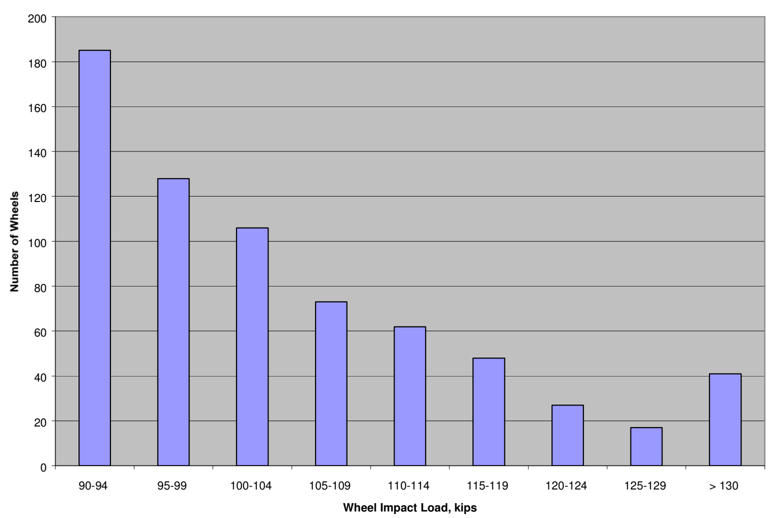

Figure 15. Red Flag Wheel Impact Load Distribution.

CFCL also looks for increases in empty car impact load readings. If a car can be shopped for wheelset changeout while empty, it will prevent delays to customer shipments. Additionally, use of databases can allow for detection of repeat offender cars and for root cause analysis.

CONCLUDING REMARKS

Determination of wheel defect root cause is important for prevention of future wheel removals and keeping maintenance costs under control. Unfortunately, if a wheel is removed for Why Made Code 65, the true reason for the wheel removal is not known. Was the air brake system on the car defective? Was the handbrake left applied and the car moved? Without answers to such questions, problems will surely happen again.

CFCL, like all private car owners, is dedicated to removing damaging wheels from service. High impact wheels, with impact loads over 90,000 pounds every 9.4 feet in service (for a 36 inch diameter wheel), are not doing anyone or anything any good. However, an AAR sponsored study group recently concluded that 97% of the economic benefits from WILD detectors will accrue to railroads. A better system of sharing both costs and benefits with all stakeholders in the railroad industry will surely lead to better cooperation and problem solving.

Also, we feel that having private car owners take a more active role, perhaps even a voting role, in the AAR rule making process will be useful for our industry.

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