2003 AAR CAR REPAIR BILLING WHEEL REMOVAL ANALYSIS

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ABSTRACT

This paper is the fifth in a series of papers on Association of American Railroads (AAR) Car Repair Billing (CRB) Wheel Removal Analysis presented at the RSA/RSI shows (Sullivan et al., 2000 through 2003). The authors reviewed and analyzed 2003 AAR Car Repair Billing data for wheel removals in North America and compared their findings with previous data. For background information and limitations on the data, please refer to the 2000 and 2001 papers.

The authors grouped wheel removals into four general categories, discussed several Why Made Codes in detail, and noted historical trends. We paid special attention to service related wheel defects, including a review of how such defects are formed. Why Made Codes associated with wheel failures are also analyzed and discussed. We reviewed the incidence of selected Why Made Codes for seven different car types and examined wheel life based on removal categories and car types. Finally, we offered recommendations to reduce the number of wheels changed for service related defects.

RWMEC

The Railway Wheel Manufacturers' Engineering Committee (RWMEC) is composed of AAR approved wheel manufacturers from around the world. RWMEC exists to support the AAR WABL Committee and the railroad industry with technical guidance related to the use and performance of railway wheels. Although not all AAR approved wheel manufacturers are currently members of RWMEC, they are invited to join.

ABOUT THE AAR CAR REPAIR BILLING DATABASE

The 2003 CRB database supplied by the AAR (AAR, 2003) contains slightly more than one half million wheel repair records. For the purposes of this paper, we assume that repairs were performed during the month they were reported. This is not always the case. Sometimes repairs are made during one month and reported to the AAR or collected by the AAR Data Exchange System at a different time. The AAR and RWMEC are aware of a carefully worded agreement with the railroads concerning appropriate use of AAR CRB data. RWMEC thanks the AAR for providing 2003 wheel repair data that is the basis of this paper. The data provided to RWMEC do not include any information that could be used to identify railroads, car owners, or wheel manufacturers.

FOUR GENERAL WHEEL REMOVAL CATEGORIES

We divided the wheel repair data into the following four general categories shown in Table 1 and Figure 1.

Category	Number Wheels Removed	% Of Total
Administrative	288437	56.21
Wear Related	77496	15.10
Environmental	146400	28.53
Wheel Failures	796	0.16

Table l. Wheel Removals by General Category.

Table 1 and Figure 1 show the number of wheel removals for each of the four general categories, Administrative, Wear Related, Environmental and Wheel Failures. When we compare the general category percentages in Table 1 to those for 2002, we note that 2003 Wear Related removals decreased by 2.2% and Environmental removals increased by 2.3%. The other categories were basically unchanged.

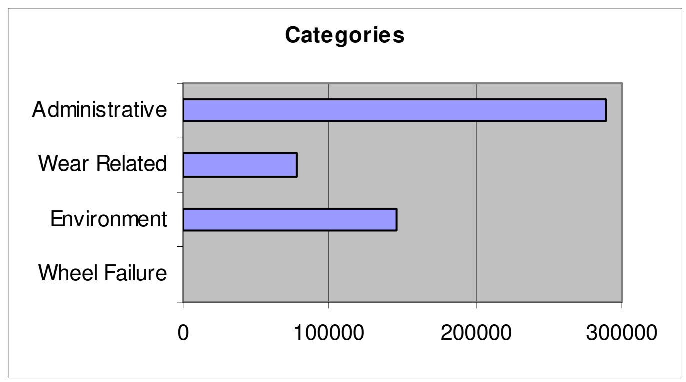

Figure 1. Wheel Removals by General Category.

Administrative wheel removals include the Why Made Codes shown in Table 2 and Figure 2.

Why Made Code	Number of Wheels
07=Obsolete Material	654
11=Removed in Good Condition	236102
23=Government Requirement	816
25=Owner's Request	912
90=Mate Wheel Scrap	48205

Table 2. Administrative Wheel Removals by Why made Code.

Between 2002 and 2003, we note that there was a reduction of 78 wheel removals for Why Made Code 07 and a reduction of 33 wheel removals for Why Made 23. This is a good indication that programs to remove obsolete material are working.

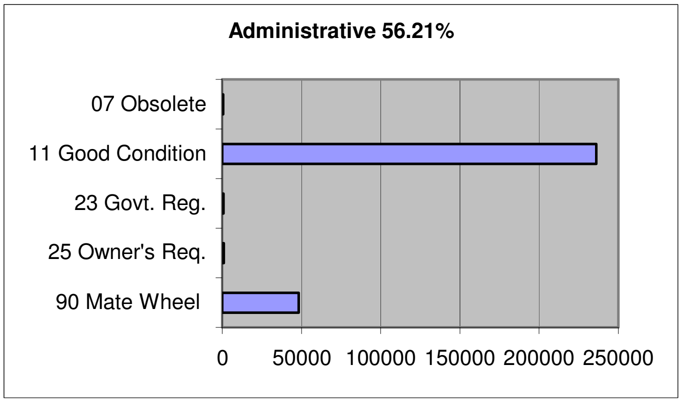

Figure 2. Administrative Wheel Removals by Why made Code.

Removals for Why Made Code 90 (Mate Wheel) decreased by more than 5,000 wheels between 2002 and 2003. Wheels removed for administrative reasons were taken out of service for failure of some other component on the wheelset.

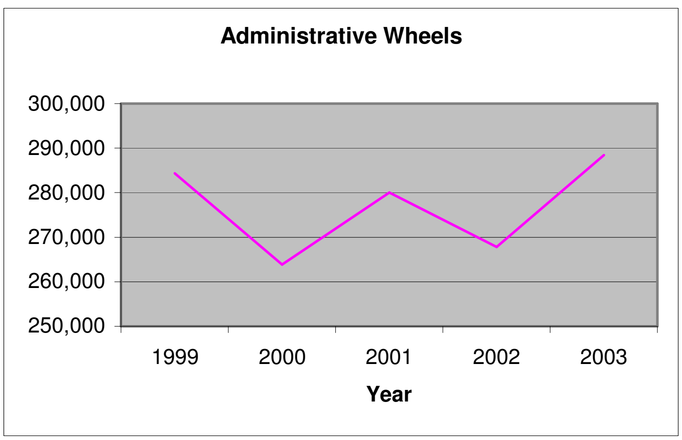

Figure 2a. Administrative Wheel Removals 5-Year Trend.

Figure 2a shows the Five-Year trend for removal of Administrative Wheels. These changes are due primarily to reporting patterns.

Wear Related wheel removals include the Why Made Codes shown in Table 3 and Figure 3.

Why Made Code	Number Of Wheels
60=Thin Flange	18952
64=High Flange	41397
73=Thin Rim	12843
98=Reapplication	4226

Table 3. Wear Related Wheel Removals by Why made Code.

For wheel manufacturers and users, wear is the best reason for removing wheels from service. The wheels are worn out and the owner received maximum service from the product. However, when compared with the removals from year 2002, the number of wheels removed for Wear Related causes is down by nearly 5,000 wheels.

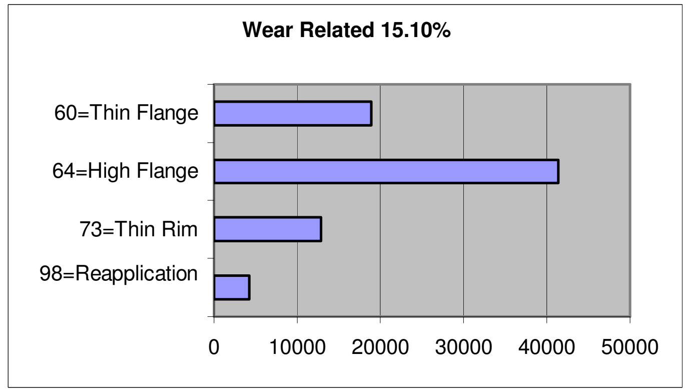

Figure 3. Wear Related Wheel Removals by Why made Code.

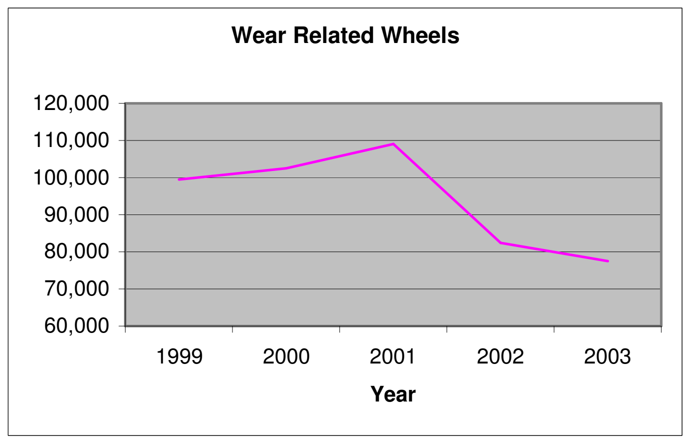

Figure 3a. Wear Related Wheel Removals 5-Year Trend.

Figure 3a shows the Five-Year trend for Wear Related Wheels. We noted a significant drop in the number of wheels removed for the years 2002 and 2003. The greatest change was a reduction in the number or high flange wheels removed.

Environmental Related wheel removals include the Why Made Codes shown in Table 4 and Figure 4**.**

Why Made Code	Number Of Wheels
65=High Impact	33011
67=Out-of-Round	10230
74=Thermal Cracks	3926
75=Tread Shelled	62689
76=Tread Build-Up	7655
78=Tread Slid Flat	23576

Table 4. Environmental Wheel Removals by Why made Code.

Given the large number of wheels removed from service for Environmental reasons, we feel that significant improvements can be made in this area.

The three most frequent causes of removal for wheels in this category were high impact, wheel shelling, and slid flat wheels. Why Made Code 65 is a new removal Why Made Code for 2003 associated with wheels removed after a high (greater than 90 kips) wayside impact detector reading.

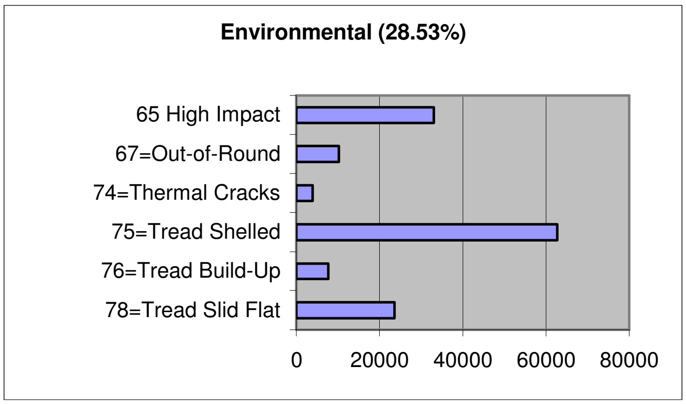

Figure 4. Environmental Wheel Removals by Why made Code.

Since most shelling is actually spalling, the root cause for the majority of these wheel removals was wheels sliding on the rail when the car was empty. While rolling contact fatigue causes shelling, spalling is caused when a small patch of martensite forms on the wheel tread. Martensite is formed when a small area of the wheel tread is heated into the austenitic zone and is quickly quenched by the colder remaining body of the wheel. Due to residual tensile stresses associated with the formation of hard, brittle martensite and subsequent service loadings, eventually pieces of the wheel tread come off the surface.

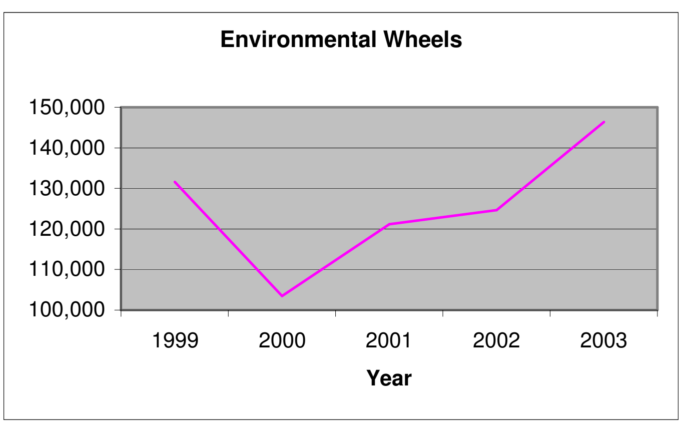

Figure 4a. Environmental Wheel Removals 5-Year Trend.

Figure 4a shows the Five-Year trend for removal of Environmental Wheels. We noted a general increase in Environmental Wheel Removals since the year 2000. The primary cause was a significant increase in the number of Why Made Codes 65 and 67 removals reported.

As shown in Figure 5, shelling/spalling (Why Made Code 75) steadily increased in the time period 1982 to 1997, but has trended downward since then.

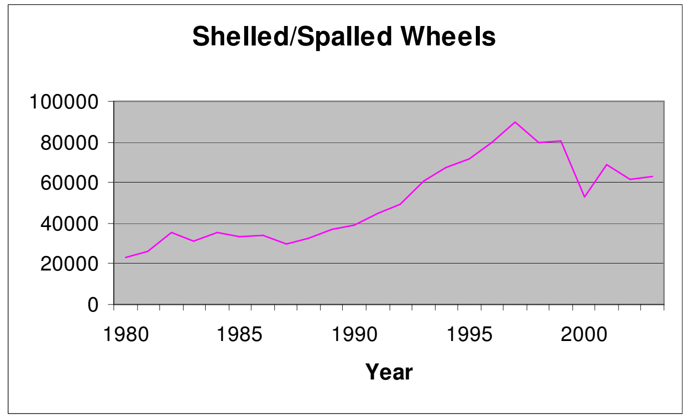

Figure 5. Trend for Shelled/Spalled Wheel Removals.

Wheels are slid flat when the handbrakes are not released, or when the empty braking ratio is such that the wheel cannot roll at some point in service. Defective air brake systems that allow air pressure to leak into the brake cylinders can also lead to sliding of the wheel on the rail. Built up tread defects are often associated with defective air brakes. Spalled, slid flat, built up tread and out of round wheels also cause large impact loads in service that can damage wheels, rails, lading and other mechanical components.

We also noted the large decrease in the removal of out-of-round wheels from 2002 to 2003 (12,255) as shown in Figure 6. We think this decrease is due to railroads reporting the wheels as Why Made Code 65 (High Impact). The number of slid flat wheels and thermal cracked wheels continues to decrease.

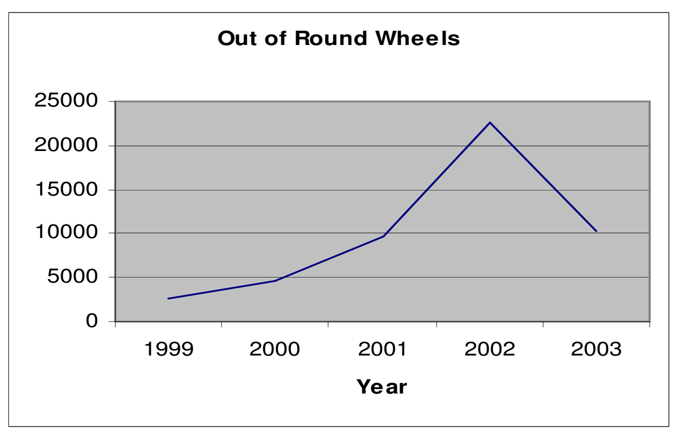

Figure 6. Out-of-Round Wheel Removals 5-Year Trend.

We note that the total number of Why Made Code 67, 75, 76 and 78 wheel removals was 114,711 in year 2002 and was 104,150 in year 2003. A large reduction in Why Made Code 67 removals was the reason for this, while slid flat removals decreased slightly (477) and built up treads increased by 877 wheels. However, the reduction was more than offset by the 33,011 additional 2003 removals for Why Made Code 65.

Wheel Failure Related wheel removals include the following Why Made Codes shown in Table 5 and Figure 7.

Why Made Code	Number Of Wheels
66=Flange Cracked	171
68=Rim Cracked	320
71=Rim Shattered	143
72=Rim Spread	100

Table 5. Wheel Failures by Why made Code.

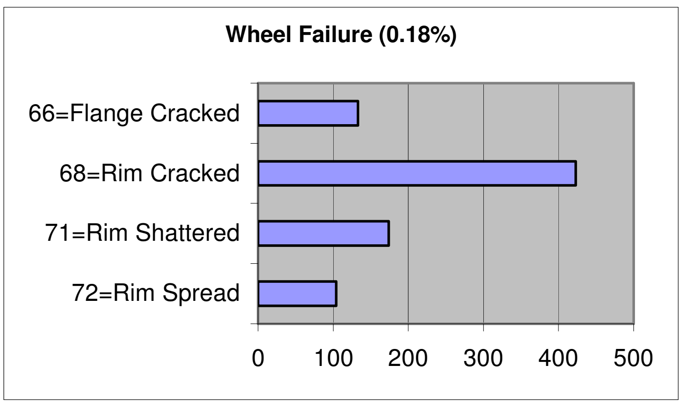

Figure 7. Wheel Failures by Why made Code.

We note that the number of Failed Wheels continues to decline. There were 100 fewer wheel failures in 2003 than in 2002.

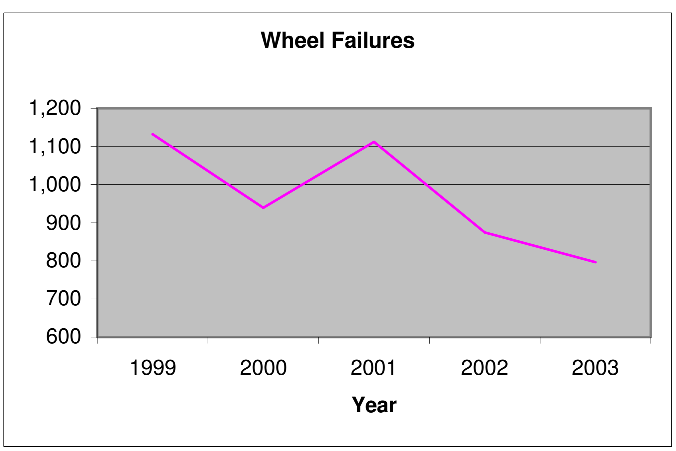

Figure 7a. Wheel Failures 5-Year Trend.

Figure 7a shows the five year trend for removal of failed wheels. We note that the number of Failed Wheels continues to decline. There were 100 fewer wheel failures in 2003 than 2002. The number of failures decreased for all major Why Made Codes.

We conducted further analysis of the Failed Wheels data based on heat treatment and plate design and the results are shown in Table 6. We noted that 20% of the year 2003 wheels removed in the Failed Wheel category were either heat-treated straight plate (HT-SP), untreated straight plate (NHT-SP) or untreated curved plate wheels (NHT-CP). This percentage is down from 30% in 2002. The remaining wheels were heat treated (rim quenched) curved plate (HT-CP) wheels.

Wheel Type	HT-CP	NHT-CP	HT-SP	NHT-SP
Failed Wheels	80%	12%	2%	6%

Table 6. Wheel Failures by Heat Treatment and Plate Shape.

The graph in Figure 8 shows the number of Failed Wheels and the year the wheels were manufactured. Note the first peak occurred in 1980 (24 wheels failed) while two more peaks occurred in 1995 and 1999 (70 and 67 wheels). The authors theorize that the large number of wheels put in service in 1979/1980 as a result of extensive new car building may be responsible for the first significant peak. A larger population of wheels could be responsible for a greater number of failures. There is no clear explanation for the 1995 and 1999 peak, but the primary cause for these removals in 1995 was cracked flange and in 1999 was wheel with cracked or broken plate. However, the 1999 wheel removals appear to be some type of program repair since they were all from flat cars.

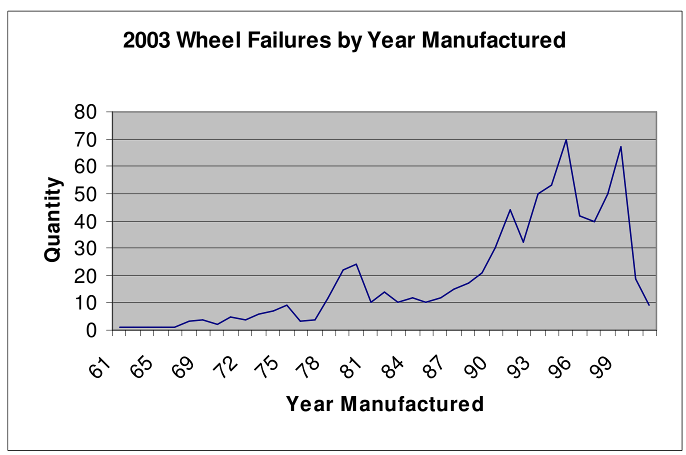

Figure 8. Wheel Failures by Year Manufactured.

FAILURE DISTRIBUTION BY WHEEL TYPE

Another way to review CRB data is to examine the number of straight plate, curved plate, untreated, and rim quenched wheels currently in service. By using AAR CRB data and the appropriate repair Job Codes, we can determine the percentages for the types of wheels in service. The two ways to make this comparison are to use raw CRB data or use an accelerated method developed by the AAR. The accelerated method the AAR uses takes into account the removal of straight plate wheels using a higher condemning limit. This accelerated method is based on the composition of wheels removed because of Why Made Code 11 - removed in good condition. Table 7 shows the results of the comparison by wheel plate shape and heat treatment type.

Wheel Type	HT-CP	NHT-CP	HT-SP	NHT-SP
AAR Raw	86.7%	8.6%	1.5%	3.2%
AAR Accel.	88.8%	8.5%	0.9%	1.8%

Table 7. Percentages of Wheels Removed by Type.

Thus, based on the accelerated removal method, the AAR estimates that the number of straight plate wheels remaining in service is 2.7%, which is lower than the straight plate wheel percentage as seen for 1999 through 2002 CRB data. The 2002 data showed an accelerated percentage of 3.3%. Therefore it does appear that straight plate wheels are being removed from service over time.

The distribution of straight plate wheels as a function of car type is shown in Table 8 and Figure 9. Note that covered hoppers, tank cars and boxcars had the highest percentage of straight plate wheel removals. When a comparison of the 2002 straight plate wheel data is made, we note that fewer straight plate wheels were removed from box cars in year 2003 (13% for 2003 vs. 17% for 2002) and slightly more straight plate wheel removals were from hopper cars. The other percentages are similar.

Type Of Car	% Removals Straight Plate
Box Cars	13
Covered Hoppers	36
Flat Cars	3
Gondolas	8
Hopper Cars	6
Tank Cars	33

Table 8. Straight Plate Wheels Removed by Car Type.

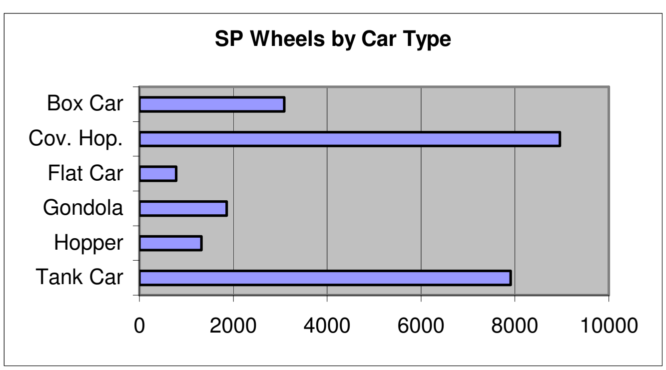

Figure 9. Straight Plate Wheels Removed by Car Type.

WHEEL REMOVALS BY YEAR MANUFACTURED

We also analyzed the wheel removals by the year of manufacture. We were trying to determine if the wheels manufactured in a particular year had a significant removal rate. The results of our analysis are shown in Figure 10.

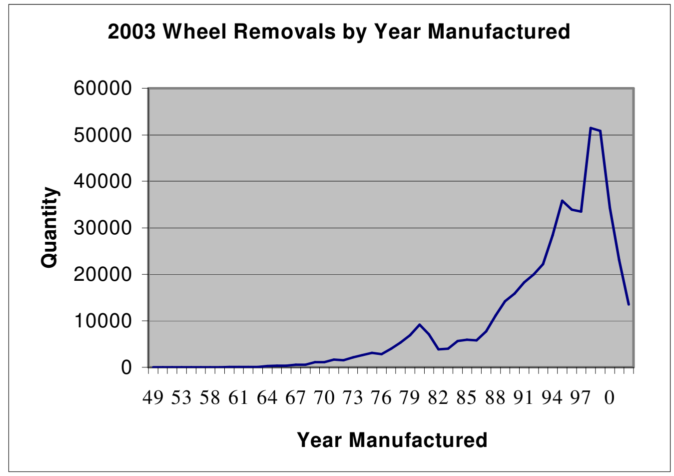

Figure 10. 2003 Wheel Removals by Year Manufactured.

The first peak was in conjunction with the massive car building efforts of 1979 and 1980. The second peak was in 1998. The primary reasons for these removals were Why Made Code 11.

AVERAGE WHEEL LIFE BY CATEGORY

We calculated the average age of wheels removed for each of the four general categories - the results are shown in Table 9.

Category	Average Wheel Life, years
Administrative	11.0
Wear related	14.0
Environmental	9.3
Wheel failure	12.6

Table 9. Average Wheel Life by General Removal Category.

In previous years there was a slight increase in the average life of all categories. This held again in 2002 for the first three categories, but there was a decrease (1.9 years) in the average life of wheels removed for failure categories.

OTHER ANALYSES

The CRB data also allowed us to determine the wheel life for different car types, as shown in Table 10. Average wheel life was indeed different for each car type with covered hoppers, tank cars, and boxcars having the longest wheel life. Wheels on articulated cars, flat cars, hoppers and gondolas had the shortest lives. Such cars likely have a higher annual mileage than other more specialized, "slower-moving" cars. Between 2002 and 2003, wheel life decreased for boxcars and covered hoppers but increased for the other car types.

Type of Car	Wheel Life, years
Box	12.9
Gondola	9.0
Hopper	10.0
Covered Hopper	12.4
Tank	13.7
Flat	9.1
Articulated	6.1

Table 10. Wheel Life by Car Type.

A review of the data in Tables 11, 12 and 13 (placed at the end of this paper) show some of the other areas we are investigating. Table 11 shows all of the major wheel removal Why Made Codes for each of the seven car types. Tables 12 and 13 show the distribution of Environmental wheel removals for each car type.

Articulated Cars

Articulated cars have many unique characteristics that cause the wheels removed from these cars to have a different pattern from wheels removed from other cars. The total number of wheels removed in good condition is low because the wheels wear out faster than the other wheelset components. It is not surprising that articulated cars have the most wheels removed for high flange, which is probably a factor why they also have the most wheels removed for "Mate Wheel." The number of articulated car wheel removals increased from 59,175 in 2002 to 64,746 in 2003. Most of the articulated car Why Made categories had little change except for tread shelled, which showed a large decrease (1984) in removals. Why Made 11 increased by 2,809 and Why Made Code 65 added 4,843.

Covered Hopper

Table 11 shows that Covered Hopper cars have the most wheels removed of the car types. Covered hopper cars and tank cars have the highest percentage rate for wheels removed for a slid flat condition. This is probably the result of the type of service these cars are in and the handbrakes not being released properly after the cars have been stationary for a long time.

Covered hopper cars have the highest number of wheels removed for thermal cracks, tread shelled and out-of-round. Covered hoppers also have the most wheels removed for built up tread, removed good condition, thin flange, thin rim and slid flat.

Flat Cars

Flat cars showed a significant decrease in the number of slid flat wheel wheels removed when compared with 2002 data (5,397 vs. 4,693).

Tank Cars

Tank cars still have a high number of wheels removed for shelling (second most of the car types) and have the second highest number of wheels removed for thermal cracks. Perhaps the higher incidence of thermal crack removals is related to older straight plate wheels being more common on tank cars and on covered hopper cars. Tank cars also have the second highest number of wheels removed for thin flange, but the numbers of wheels removed for slid flat have declined when compared with the 2002 data.

Gondolas

Gondolas have the second most wheel removals for out-of-round of the various car types.

Hopper Cars

Surprisingly, hopper cars have the fewest wheel removals for thermal cracks and scrapes/dents. Hoppers also have the lowest number of wheel removals for shelling.

General Comments

Tables 12 and 13 show that shelling is still the number one environmental wheel removal cause for all seven car types, and slid flats and out-of-round are the second and third most numerous. Built up tread is the third leading cause of wheel removals for most car types.

Table 13 shows that of the seven car types, covered hopper cars have the most wheel removals for shelling and the most wheel removals for out-of-round.

Analysis by Wheel Size

We examined the effects of wheel size (diameter) on 2003 CRB removals. We did this by using Job Codes associated with 28-inch, 33-inch, 36-inch and 38-inch wheels to get total removals by wheel size, then calculated percentages of selected removal Why Made Codes for each wheel size. We note that 28-inch and 38-inch wheels are predominantly in service on type A (articulated) and type F (flat car) equipment while the 33-inch and 36-inch wheels are in service on a mixture of equipment types. The vast majority of removals were for 36-inch wheels, followed by 33-inch wheels. Removals for 28-inch and 38-inch wheels were each less than 10% of the total removals for 36-inch wheels. We also noted a significant decline in the use of 33 inch and 36 inch multi-wear wheels. Data showing the removals by wheel size are contained at the end of the paper in Table 14.

High flange wheels are more common for 28-inch, 33-inch and 38-inch wheels than for 36-inch wheels. The authors believe this is due to the high service utilization of type A and type F equipment (more miles traveled), thus leading to more removals for tread wear instead of other removal causes. Removals for shelling and high impact are more common for 36-inch and 38-inch wheels than for 28-inch or 33-inch wheels, which is reasonable since the larger wheels carry heavier loads. Also, 36-inch wheels have a higher percentage of wheels removed for slid flat, thin flange, built-up-tread and out-of-round than the other three wheel sizes. This is likely due to several factors including: 1) a greater likelihood of general-service cars having hand brakes left on, 2) defects in older air brake systems and 3) heavy loading of most 36-inch wheels.

We note that 28-inch and 38-inch wheels have a low incidence of slid flat. This could be due to infrequent handbrake applications (hence infrequently left on) for cars in intermodal service. Also, built-up-tread removals are least common for 28-inch and 38-inch wheels. If cars using these wheel sizes are newer (thus with newer air brake systems), this could provide a possible explanation.

RWMEC RECOMMENDATIONS

The railroad industry has already implemented several actions that will improve wheel service life and wheel safety including ultrasonic inspection of turned wheels, an improved ultrasonic specification for new wheels, improved track condition, etc.

The program to accelerate the removal of inferior straight plate wheels has a goal of removing wheels from service that were manufactured based on old technology. We feel that consideration should also be given for a program to accelerate removals of untreated curved plate wheels (approximately 8.5% of the wheel population) and we will suggest changing the rules accordingly. Such untreated wheels do not have the beneficial compressive residual stresses in the wheel rim that are imparted by rim quenching operation and they have softer rims with reduced fatigue resistance. As the percentage of heat-treated curved-plate wheels increases, the overall population of the wheels will be safer and will last longer.

Also, improved air brake testing methods, to include use of brake cylinder pressure testing, helps to identify cars with defective air brake systems before brake related wheel defects are caused.

Earlier we noted the problems associated with improper reporting of wheel data. We feel that the CRB database is an extremely valuable tool for analyzing wheel performance. However, we estimate that ten percent of the data were not reported properly and this limits the value of the database. The wheel manufacturers are helping by improving their wheel marking procedures with more automated equipment. The new markings should last longer and be easier to read in the future. We helped the WABL Committee develop rule changes that will increase the life of wheel markings.

Due to recent notable problems with some wheels in North American service, there has been a great deal of scrutiny placed on wheels. 2003 AAR CRB data show the percentage of wheel failures continues to be very low and significantly more money is being spent for removal of wheels with environmental defects. Reducing the number of early environmental wheel removals for spalling, slid flats, built up tread, thermal cracks and out of round wheels can save the railroad industry significant capital.

RWMEC members support the work of the AAR Wheel Research Consortium. This group, composed of railroads, wheel manufacturers and the FRA, is working on ways to reduce shattered rim and vertical split rim wheel failures and to reduce the incidence of wheel shelling/spalling.

Also, a video on the subject of proper handbrake use was produced and distributed and work on a graduated empty/load device is underway. Railroads and other companies that handle freight cars should train their employees about the proper use of handbrakes. RWMEC hopes to raise awareness of the costs associated with environmental wheel removals, including those removals caused by improper handbrake use, through publication of this report.

CONCLUDING REMARKS

RWMEC members are participating in the Wheel Research Consortium with AAR/TTCI, and some members have joined in efforts to develop a new spall-resistant alloy. These programs are underway and will focus on reducing the incidence of wheel shelling/spalling and other wheel defects.

RWMEC was formed to provide technical support to the AAR WABL Committee and the railroad industry with regard to use and performance of railway wheels. We look forward to continued cooperation with the AAR and the railroad industry in reducing wheel failures and improving wheel service life.

The very high costs associated with Environmental wheel removals should be viewed as an unacceptable allocation of capital within the railroad industry. Railroads, private car owners and other stakeholders should continue efforts to reduce the money spent on these defects while improving wheel safety.

RWMEC will continue to closely review information from the AAR CRB database as a service to the North American railroad industry. Progress reports will be distributed to the AAR WABL Committee as such reports become available.

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AAR 2003 Car Repair Billing Data, Association of American Railroads, Pueblo CO.

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Why Made Code	All Cars		Articulated Cars		Box Car		Flat Car		Gondola		Hopper		Covered Hop.		Tank	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
11 Good Condition	229017	46.5%	17996	27.8%	29614	50.6%	29335	45.0%	36484	51.8%	17159	51.4%	58445	49.7%	39981	48.7%
23Govt. Reg.	750	0.2%	5	0.0%	60	0.1%	26	0.0%	42	0.1%	16	0.0%	373	0.3%	228	0.3%
60 Thin Flange	18076	3.7%	1405	2.2%	2116	3.6%	2269	3.5%	2830	4.0%	1952	5.8%	4425	3.8%	3079	3.7%
64 High Flange	38790	7.9%	15013	23.2%	3368	5.8%	8657	13.3%	3351	4.8%	1928	5.8%	3795	3.2%	2677	3.3%
65 High Impact	32666	6.6%	4843	7.5%	2536	4.3%	4452	6.8%	6858	9.7%	2616	7.8%	6254	5.3%	5107	6.2%
66 Flange Cracked	165	0.0%	6	0.0%	17	0.0%	10	0.0%	36	0.1%	8	0.0%	63	0.1%	25	0.0%
67 Out of Round	10110	2.1%	1877	2.9%	807	1.4%	1356	2.1%	1833	2.6%	1002	3.0%	2113	1.8%	1122	1.4%
68 Rim Cracked	308	0.1%	40	0.1%	26	0.0%	45	0.1%	49	0.1%	33	0.1%	77	0.1%	38	0.0%
71 Rim Shattered	116	0.0%	16	0.0%	11	0.0%	20	0.0%	9	0.0%	18	0.1%	23	0.0%	19	0.0%
73 Thin Rim	12152	2.5%	1521	2.3%	2052	3.5%	1311	2.0%	810	1.1%	589	1.8%	3293	2.8%	2576	3.1%
74 Thermal Cracks	4326	0.9%	51	0.1%	362	0.6%	191	0.3%	270	0.4%	42	0.1%	1971	1.7%	1439	1.8%
75 Tread Shelled	61479	12.5%	4702	7.3%	6279	10.7%	6817	10.5%	9800	13.9%	2815	8.4%	19072	16.2%	11993	14.6%
76 Tread Built Up	7534	1.5%	257	0.4%	1079	1.8%	460	0.7%	850	1.2%	778	2.3%	2685	2.3%	1425	1.7%
77 Tread Grooved	1124	0.2%	207	0.3%	190	0.3%	156	0.2%	126	0.2%	18	0.1%	234	0.2%	193	0.2%
78 Slid Flat	23045	4.7%	945	1.5%	3121	5.3%	2380	3.7%	3141	4.5%	2320	6.9%	6445	5.5%	4693	5.7%
80 Scrape/Dent	3768	0.8%	310	0.5%	600	1.0%	333	0.5%	348	0.5%	126	0.4%	1227	1.0%	824	1.0%
90 Mate Wheel	44809	9.1%	15293	23.6%	5396	9.2%	6785	10.4%	3328	4.7%	1805	5.4%	6202	5.3%	5999	7.3%
98 Reapplication	3863	0.8%	259	0.4%	920	1.6%	556	0.9%	273	0.4%	161	0.5%	944	0.8%	750	0.9%
Total	492092		64746		58554		65159		70438		33386		117641		82168	

Table 11 Distribution of Wheel Removals - Why Made Code by Car Type.

Why Made Code	Articulated Car		Box Car		Flat Car		Gondola		Hopper		Covered Hopper		Tank	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
65 High Impact	4843	37.30%	2536	17.15%	4452	27.84%	6858	29.69%	2616	26.97%	6254	15.73%	5107	19.20%
67 Out of Round	1877	14.46%	807	5.46%	1356	8.48%	1833	7.94%	1002	10.33%	2113	5.31%	1122	4.22%
74 Thermal Cracks	51	0.39%	362	2.45%	191	1.19%	270	1.17%	42	0.43%	1971	4.96%	1439	5.41%
75 Tread Shelled	4702	36.21%	6279	42.47%	6817	42.64%	9800	42.42%	2815	29.02%	19072	47.96%	11993	45.08%
76 Tread Built Up	257	1.98%	1079	7.30%	460	2.88%	850	3.68%	778	8.02%	2685	6.75%	1425	5.36%
78 Slid Flat	945	7.28%	3121	21.11%	2380	14.89%	3141	13.60%	2320	23.92%	6445	16.21%	4693	17.64%
80 Scrape/Dent	310	2.39%	600	4.06%	333	2.08%	348	1.51%	126	1.30%	1227	3.09%	824	3.10%
Total	12985	100.00%	14784	100.00%	15989	100.00%	23100	100.00%	9699	100.00%	39767	100.00%	26603	100.00%

Table 12 Distribution of Environmental Why Made Codes by Car Type.

Car Type	65 High Impact		67 Out-of Round		74 Thermal Cracks		75 Tread Shelled		76 Tread Built Up		78 Slid Flat		80 Scrape/Dent	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Articulated	4843	14.83%	1877	18.57%	51	1.18%	4702	7.65%	257	3.41%	945	4.10%	310	8.23%
Boxcar	2536	7.76%	807	7.98%	362	8.37%	6279	10.21%	1079	14.32%	3121	13.54%	600	15.92%
Flat Car	4452	13.63%	1356	13.41%	191	4.42%	6817	11.09%	460	6.11%	2380	10.33%	333	8.84%
Gondola	6858	20.99%	1833	18.13%	270	6.24%	9800	15.94%	850	11.28%	3141	13.63%	348	9.24%
Hopper	2616	8.01%	1002	9.91%	42	0.97%	2815	4.58%	778	10.33%	2320	10.07%	126	3.34%
Cov. Hop.	6254	19.15%	2113	20.90%	1971	45.56%	19072	31.02%	2685	35.64%	6445	27.97%	1227	32.56%
Tank	5107	15.63%	1122	11.10%	1439	33.26%	11993	19.51%	1425	18.91%	4693	20.36%	824	21.87%
Total	32666	100.00%	10110	100.00%	4326	100.00%	61478	100.00%	7534	100.00%	23045	100.00%	3768	100.00%

Table 13 Distribution of Car Types by Environmental Why Made Codes.

Why Made Code	**28" Wheels**		**33" Wheels**		**36" Wheels**		**38" Wheels**	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
11 Good Condition	5170	44.48%	45918	39.96%	179651	49.48%	5361	28.16%
60 Thin Flange	984	8.47%	3550	3.09%	13685	3.77%	733	3.85%
62 Vertical Flange	2	0.02%	32	0.03%	42	0.01%	2	0.01%
64 High Flange	2325	20.00%	21952	19.11%	14435	3.98%	2683	14.09%
65 High Impact	241	2.07%	2792	2.43%	27261	7.51%	2717	14.27%
66 Flange Broken	3	0.03%	17	0.01%	148	0.04%	3	0.02%
67 Out of Round	80	0.69%	1399	1.22%	8008	2.21%	723	3.80%
73 Thin rim	286	2.46%	4383	3.81%	7811	2.15%	363	1.91%
74 Thermal Cracks	3	0.03%	592	0.52%	3851	1.06%	66	0.35%
75 Tread Shelled	326	2.80%	6106	5.31%	54323	14.96%	1934	10.16%
76 Tread Build-Up	6	0.05%	1254	1.09%	6372	1.75%	23	0.12%
77 Tread Grooved	61	0.52%	416	0.36%	653	0.18%	29	0.15%
78 Slid Flat	32	0.28%	3080	2.68%	20228	5.57%	236	1.24%
80 Scrape	54	0.46%	526	0.46%	3201	0.88%	106	0.56%
90 Mate Wheel	1886	16.23%	21128	18.39%	21162	5.83%	4029	21.16%
98 Reapplication	164	1.41%	1756	1.53%	2278	0.63%	29	0.15%
Total	11623	100.00%	114901	100.00%	363109	100.00%	19037	100.00%

Table 14. Distribution Based on Wheel Size.