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High-Performance Wheels: 320,000-Mile Update

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Summary

Since 2008, Transportation Technology Center, Inc. (TTCI) has been conducting long-term testing of high performance wheels (HPWs) in laboratory, accelerated service, and revenue service environments. The laboratory testing portion of the program is detailed in a previous *Technology Digest*.[1] The durability testing was conducted at the Facility for Accelerated Service Testing (FAST) at the Transportation Technology Center (TTC) in Pueblo, CO. The revenue service test began in 2009 and is ongoing on a North American railroad.

After 320,000 miles, HPW showed better durability that other types of Class C wheels.

The durability test began in 2008 with eight types of high performance wheels, as well as Class C wheels for comparison. Two to three wheelsets of each type were placed in the train. Two additional types, SRI-B and Type 9, began running in 2013. Type 9 is the only wheel type remaining in the test. All others have been removed for subsurface cracks, high impacts or shattered rims. Shattered rims occurred in several of the HPWs. These wheel types then were removed from the revenue service test.

Four types of high performance wheels (HPWs) and a control group of Class C wheels remain in the revenue service test. The wheels have travelled an average of 320,000 miles. Twenty-four of the Class C wheelsets have been removed for shelling or high impact, while 14 of the HPWs have been removed for the same causes. Type 2 has zero removals in revenue service. The three best performing HPWs, Types 1, 2, and 5, have only seven removals combined. Data analysis reveals that Types 1, 2, and 5 have developed condemnable high impacts or shelling at significantly lower rate than the Class C wheels.

Inspections of the wheel treads revealed a wide variety of conditions, ranging from small pits and surface cracks to significant shells and material loss. Ultrasonic testing was added to the inspection process in 2014. Indications of subsurface cracks were detected in two wheelsets and these wheelsets were removed from the test.

Type 1 wheels show more wear on the flange width than the other types. Six Type 1 wheelsets have been removed for thin flanges. No significant differences were found in the hollow wear of the HPWs or Class C wheels.

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INTRODUCTION

Since 2008, TTCI has been conducting long-term testing of high performance wheels in laboratory, accelerated service, and revenue service environments. The requirements for Class D wheels were not defined at the time the test began, so the wheels became known as high performance wheels, or HPWs.

The laboratory portion testing of the HPWs is detailed in a previous *Technology Digest*.[1] The durability testing was conducted at the Facility for Accelerated Service Testing (FAST) in Pueblo, CO. The revenue service test is ongoing on a North American railroad.

WHEEL TYPES IN HPW TEST

Eight high performance wheel types initially were used in the test. AAR Class C wheels were used as a control. One HPW was developed in part by TTCI, as part of AAR's Strategic Research Initiative (SRI). This was designated the SRI wheel[1] and was produced by two different manufacturers. The first version of the SRI wheel (SRI-A) encountered performance issues and was removed from the TTC and revenue service tests. The second version (SRI-B) has not been installed in revenue service, but 16 wheelsets were installed on cars at TTC. One additional steel, designated Type 9, began running in 2013.

DURABILITY TEST AT TTC

Two to three wheelsets from each supplier initially were in the durability test.2 Currently, Type 9 is the only HPW remaining in the durability test, with an average of 106,000 miles. All others have been removed for subsurface cracks, high impact loads, wear, or shattered rims. Shattered rims occurred in several of the HPWs. These wheel types were removed from the revenue service test.

Sixteen SRI-B wheelsets were installed in the FAST train in January 2013. They have run an average of 73,000 miles at FAST.

REVENUE SERVICE TEST

Wheel removals

As mentioned previously, Types 3, 4, and SRI-A experienced several shattered rims at FAST; Type 6 experienced deep shelling and excessive wear. These were removed from revenue service. Only four types of HPWs and the Class C wheels remain. A summary of the remaining wheel types in the revenue service test is shown in Table 1. Wheel removals caused by high impact or shelling are counted as a failure; other causes do not count as failures.[3] There have been no Type 2 wheels removed for cause.

Table 1. Summary of HPW1 wheelsets in revenue service.

Wheel Type	Initial Wheelset Count	Average Mileage, Miles	Wheelsets Removed for Cause
1	27	337,000	2
2	28	331,000	0
5	25	312,000	5
7	25	310,000	7
Class C	124	308,000	24

Of the 14 removals for HPWs, half are Type 7 wheels. Removing this type leaves the three best performing HPWs. The mileage and removal data were used to construct a probability plot for the Class C wheels versus the HPWs and is shown in Figure 1. Each point on the graph represents a removal for shelling or high impact. The center line for each wheel type predicts the probability of failure at a given mileage. The curved outer lines for each wheel type indicate the 95-percent confidence intervals. The plot in Figure 1 produces overlapping confidence intervals but significantly different slopes. The slope of the Class C line is steeper than the Types 1, 2, 5 line. This indicates that Class C wheels develop condemnable shelling or high impacts at a higher rate than the HPWs.

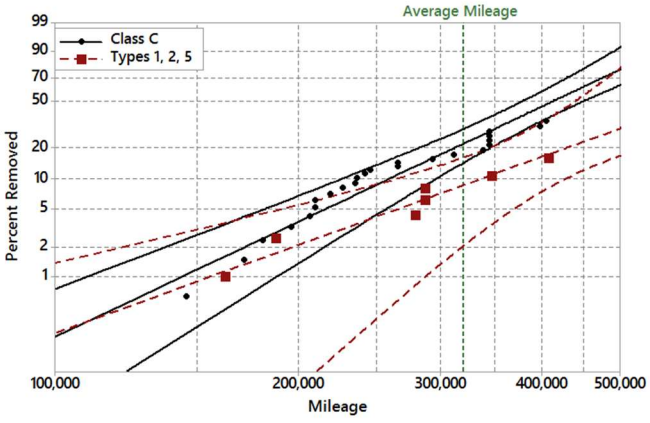

Figure 1. Probability plot of HPW and Class C wheels.

Surface Condition

A variety of tread conditions were found during the visual inspections. Conditions ranged from small pits and surface cracks to large shells. In 2014, TTCI began ultrasonic testing for the wheels in the test.[4] Examples of wheel tread conditions are given in Figures 2 and 3.

The wheelset in Figure 2 showed small pits and fine surface cracks, as well as some hollow wear. It also has the highest mileage of any wheelset in the test.

The wheelset in Figure 3 had heavy surface damage. A slide had also occurred, as seen near the top of the picture. In addition, ultrasonic testing revealed several subsurface cracks. The wheelset was soon removed because of high impacts.

Figure 2. Fine surface cracks in an HPW after 430,000 miles. Wheelset currently has 480,000 miles.

Figure 3. Tread damage on an HPW (317,000 miles).

Wheel wear

The wheel profiles of several test wheels were compared against their original profiles to show how much wear has occurred. The last measurement occurred in December 2015. The cars with test wheels no longer are in the same train, so fewer wheelsets can be inspected. This led to small sample sizes for these wear measurements. All wear measurements in this *Technology Digest* were normalized by dividing the wear by the mileage, then multiplied by 10^6 to get an easily readable number.

The flange width wear of the HPW and Class C wheels is shown in Figure 4.

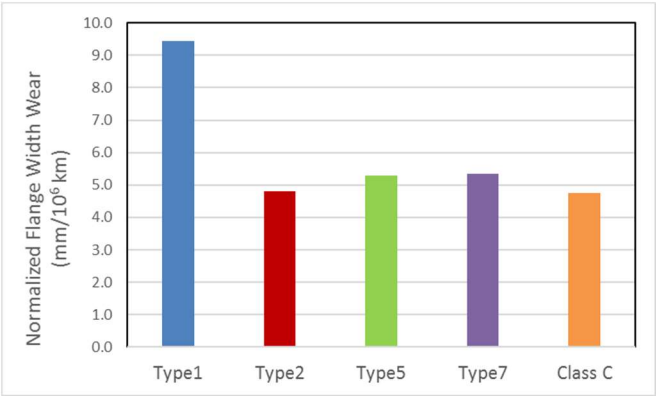

Figure 4. Flange width wear for HPW and Class C wheels

The Type 1 wheels showed significantly more flange width wear than the other HPW wheels and the Class C wheels. There was little difference between Types 2, 5, 7, and Class C. To date, one Class C wheel and six HPWs have been removed for thin flange.

Figure 5 shows the normalized tread hollowing wear of the HPW wheels and the Class C wheels. Statistically, there was no difference between these groups. None of the test wheels have been removed for hollow wear.

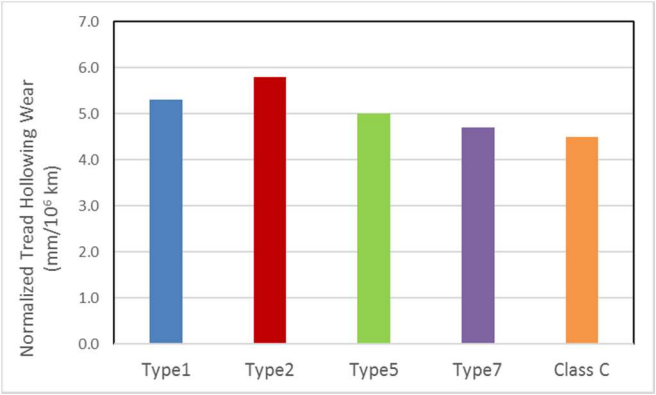

Figure 5. Tread hollowing wear for HPW and Class C wheels.

FUTURE WORK

The HPW1 revenue service test continues with regular updates from the railroad on impact data, mileage, and wheel removals. As new data is received, it will be analyzed and updated.

CONCLUSIONS

In the revenue service test, the Type 1 wheels show more flange width wear than the Class C wheels or other HPWs. Hollow wear among the different wheel types is not significant. Fourteen HPWs have been removed for high impact or shelling, compared to 24 Class C wheels. A probability plot of the three best performing HPWs versus Class C wheels shows a significantly lower removal rate for the HPW Types 1, 2, and 5.

References

1. Robles Hernández, Francisco and Semih Kalay. "Properties and Microstructure of High Performance Wheels" *Technology Digest* TD-09-001. AAR/TTCI, Pueblo, CO, January 2009.
2. Cummings, Scott. "Drag Brake and Durability Tests of High Performance Wheels" *Technology Digest* TD-09-005. AAR/TTCI, Pueblo, CO, February 2009.
3. Cummings, Scott. "Revenue Service Test of High Performance Wheels: 23,000-Mile Interim Results" *Technology Digest* TD-10-021. AAR/TTCI, Pueblo, CO, July 2010.
4. Jones, Kerry and Megan Archuleta. "High Performance Wheel Test: 270,000-Mile Interim Results" *Technology Digest* TD-15-015. AAR/TTCI, Pueblo, CO, June 2015.