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Update: Comparison of Class C and High Performance Wheels

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Summary

Since 2008, Transportation Technology Center, Inc. (TTCI) has been conducting long-term testing of high performance wheels in laboratory, accelerated service, and revenue service environments. The high performance wheel types in test at the Facility for Accelerated Service Testing (FAST) show no statistical differences for flange wear or for tread hollowing. In revenue service testing, one wheel type has shown significantly more flange wear than other types. Tread hollowing shows little difference between the various wheel types.

Background information concerning mechanical and metallurgical property evaluation and earlier service testing can be found in TD-15-032.[1]

TTCI conducted a variety of mechanical and metallurgical testing and evaluation for each of the wheel steels in the test. An accelerated test representing the eight wheel types began in 2008 at the Facility for Accelerated Service Testing (FAST) located at the Transportation Technology Center, (TTC) Pueblo, Colorado. Several types of high performance wheels experienced shattered rims at FAST and were removed. Currently, one of the original wheel types remains in the test, with an average distance of 140,000 miles traveled. An additional wheel type, developed at TTC, was added in 2013; it is displaying good shelling resistance and has accumulated 59,000 miles to date.

In 2009, the test expanded to revenue service on a western United States railroad. The same wheel types used in the accelerated test were placed under cars in a unit coal train. AAR Class C wheels were used as a control group. Twenty-five to thirty wheelsets of each high performance wheel type were used, while 126 Class C wheels were used. TTCI personnel have conducted semiannual inspections of the wheels to assess the tread condition and wheel profile. Seven high performance wheelsets and 18 AAR Class C wheelsets have been removed for shelling or high impact wheels. The remaining high performance wheels have accumulated an average of 306,000 miles; the Class C wheels have an average of 293,000 miles.

The next high performance wheel test, designated HPW2, is scheduled to begin in late 2016. It will include new types of high performance wheels, as well as the top performers from the first test. Additional manufacturers and multiple railroads will participate in the new test.

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INTRODUCTION AND BACKGROUND

In 2007 under the AAR Strategic Research Initiatives (SRI) Program, TTCI began an evaluation of improved wheel steels, first performing laboratory evaluations. Testing began at FAST in 2008, then in revenue service the next year. The laboratory testing and previous performance data is available in previous *Technology Digests*.[1,2,3]

ACCELERATED TESTING AT FAST

In 2008, durability testing of the wheels began at FAST. The wheelsets were placed under 286,000-pound and 315,000-pound cars. Surface condition and wheel profiles were monitored two times per year. Table 1 is a summary of the remaining wheelsets in the test at FAST. Wheel Types 3, 4, 6, and Foreign Sourced SRI (FS-SRI) experienced shattered rims or excessive wear and were subsequently removed.[3] The Domestically Sourced SRI (DS-SRI) wheel, developed at TTC and produced in the United States, entered the test in 2013.

Currently, Types 2 and DS-SRI wheels are still running at FAST. The Type 7 wheelset is currently not running due to a non-wheel related issue, so the data for this wheelset is included. None of the Type 2 wheels have been removed. Types 2 and 7 have accumulated the most distance, with an average of 140,000 miles. The DS-SRI wheelsets have only been in the test since early 2013, so their accumulated distance is less than other types. One DS-SRI wheelset has been removed for high impact. Most of the remaining wheels show surface initiated cracks, but material breakout from these is small.

Table 1. Results of the test at FAST

Wheel Type	Initial Wheel-sets	Current Wheel-sets	Removed for Shelling or High Impact	Average Distance Travelled, miles
2	3	3	0	147,000
7	3	1	2	120,000
DS-SRI	16	14	1	59,000

Wheel wear was calculated by measuring the wheel profiles over time. Previous measurements used the parameters S_d, S_h, and qR, as shown in Figure 1; however, these parameters gave inconsistent results with long-term wear.

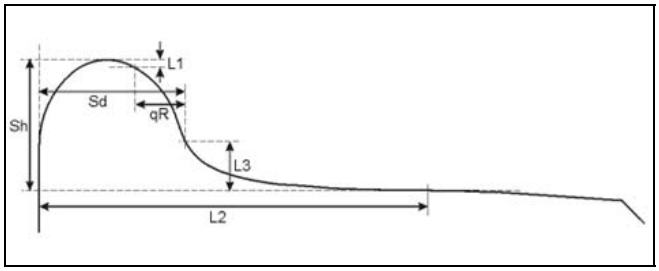

Figure 1. Parameters used in previous wheel wear measurements

To maintain consistent measurements, flange width (w) and hollowing (d) were used as wear parameters. These are shown in Figure 2.

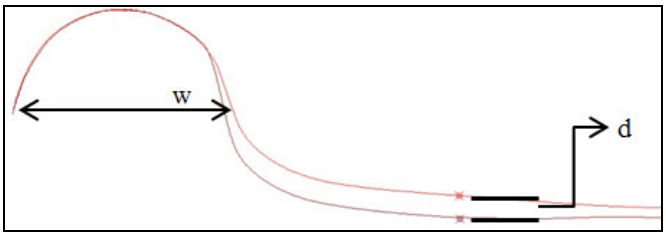

Figure 2. Current wear parameters

Because of the large mileage differences between the wheel types, the wear values were normalized using the distance traveled for each wheel type, then multiplying by a linear factor. The normalized flange wear and the normalized hollowing values are shown in Figures 3 and 4, respectively.

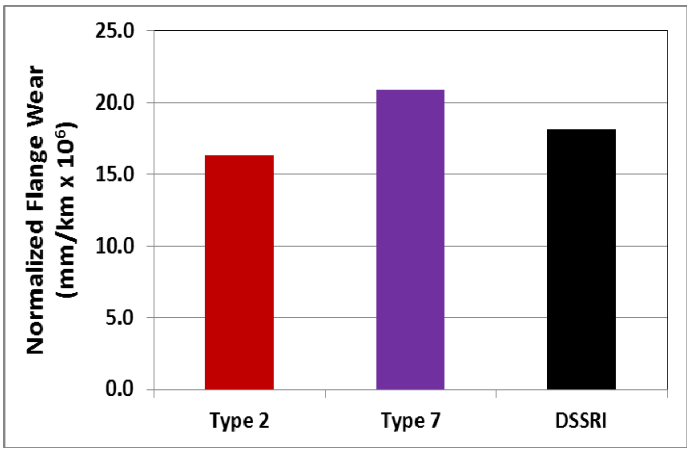

Figure 3. Normalized flange wear for wheelsets at FAST

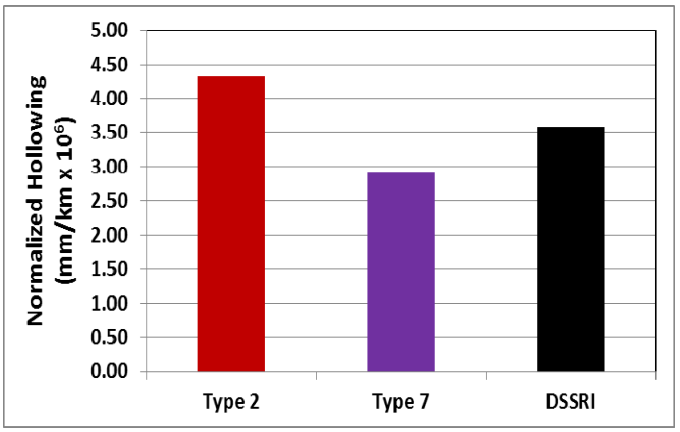

Figure 4. Normalized hollowing data for wheelsets at FAST

Wheel Type 2, which has had no removals, shows the lowest flange wear, but the largest hollowing. Two of the Type 2 and two of the DS-SRI wheelsets are approaching their hollow wear limits and may need to be re-profiled soon.

REVENUE SERVICE TESTING

In 2009, the test expanded to revenue service in a unit coal train on a western United States railroad. With the exception of the DS-SRI wheels, the same high performance wheel types were used in this portion of the test. All railcars used in this test were steel coal cars. AAR Class C wheels from various manufacturers were used as a control group. Some of them were used with high friction composition brake shoes and were designated CMP. The remaining AAR Class C wheels were equipped with tread conditioning brake shoes, designated TC-A.

Most of the cars used the same wheel type on all axles; however, not all wheelset types were available in multiples of four, so some cars contained multiple wheel types.[3] Since 2010, TTCI personnel have conducted visual inspections and obtained profile measurements of the wheels. The cars are no longer in the same unit train, but have since been dispersed throughout the system. Because of this, fewer wheelsets have been inspected during more recent inspections. Some of the cars are inactive due to business demands or damage; these inactive cars are not included in mileage averages.

Table 2 summarizes the initial and current number of the different types of wheelsets in the revenue service test.

Table 2. Wheelset Data for the Revenue Service Test

Wheel Type	Initial Wheelsets	Current Wheelsets	Removed for High Impact
1	29	15	1
2	28	19	0
5	25	16	1
7	25	10	5
All HPW*	107	60	7
Class C	126	86	18

*HPW = high performance wheel

As previously mentioned, Types 3, 4, 6, and FS-SRI high performance wheels experienced shattered rims or excessive wear at FAST. As a result, they were also removed from the revenue service test as a safety precaution.

Seven high performance wheels have been removed for shelling or high impact, and 18 AAR Class C wheels have been removed for the same reasons. The three best performing high performance wheels have only three of these removals among them. Table 3 shows the average mileage accumulated to date in the test.

Table 3. Average Mileages for Wheels in the Revenue Service Test

Wheel Type	Average Mileage Active Wheels
Class C	293,000
HPW	306,000

Further analysis of the wheel life and removal data using Weibull analysis yields more information about the removals of the AAR Class C and high performance wheels (see Figure 5). Each point on the probability plot represents a wheel removed for high impact or shelling; approximately 15 percent of the AAR Class C and 7 percent of the high performance wheels have been removed for these causes. The average mileage and highest mileage are given by the two vertical lines.

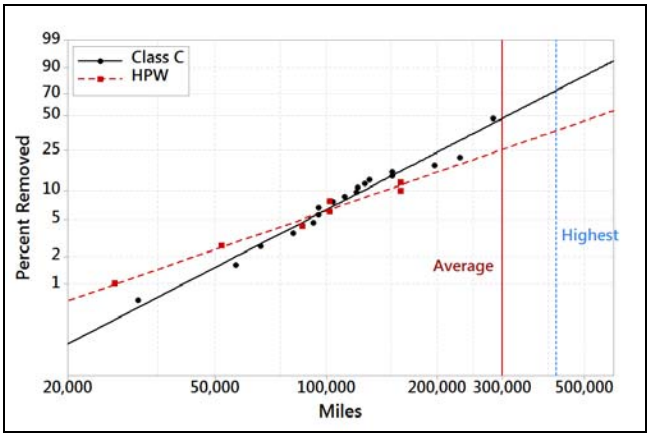

Figure 5. Weibull Probability Plot for AAR Class C and High Performance Wheels

Because of the relatively small number of high performance wheel removals, the confidence intervals for the projected wheel life are wide and overlap the confidence intervals for the Class C removals; therefore, current data does not show a statistical difference between the Class C and high performance wheels. Further mileage and high impact wheel removals will tighten the confidence intervals.

Many of the wheels showed some degree of surface damage, most having surface cracks initiated by scuffing (see Figure 6). Small pits were also present in some wheels. Some wheels showed very little surface damage; Figure 7 shows a wheel that has accumulated over 420,000 miles with minimal surface damage.

Figure 6. Surface cracks caused by scuffing

Figure 7. Tread surface showing minor pitting after 421,000 miles

The wheel wear was measured with the same normalized flange width (w) and hollowing (d) parameters used in the FAST measurements. Average flange width and hollowing results for the different wheel types are given in Table 4 and are shown graphically in Figures 8 and 9, respectively. The values represent comparisons of the wheels with their initial profiles.

Table 4. Flange width and hollowing data for wheels in the revenue service test

Wheel Type	Wheels Tested	Average Flange Width Difference	Average Hollowing
1	10	5.85	3.29
2	13	3.17	3.84
5	6	3.05	2.85
7	6	2.74	2.34
CMP	9	3.02	2.32
TC-A	17	2.12	2.70
All HPW	35	3.84	3.25
All Class C	26	2.43	2.57

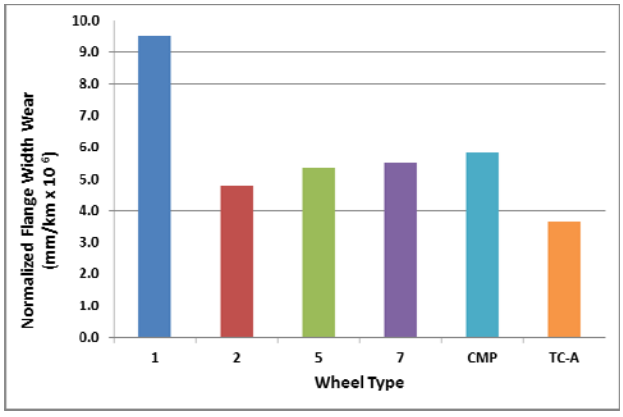

Figure 8. Flange width differences in revenue service test

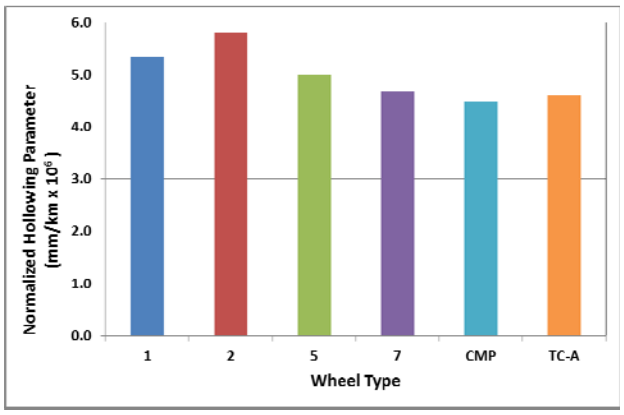

Figure 9. Hollowing results from the revenue service test

SUMMARY AND CONCLUSIONS

The high performance wheel steels were designed with enhanced properties to increase the service life compared to the AAR Class C wheels.

The Type 2 (140,000 miles) and DS-SRI (59,000 miles) wheels remain in the test at FAST. A few are approaching their hollowing limits and many show surface initiated cracking, but there is little material loss from the cracks.

In the revenue service test, the high performance wheels have an average of 306,000 miles and 7 removals, whereas the AAR Class C wheels have 293,000 miles and 18 removals. The high performance wheels have more overall wear than the AAR Class C wheels, but also have fewer removals.

The FAST and revenue service tests will continue through the end of 2016. TTCI has invited suppliers to participate in a new high performance wheel test in 2016. This new test, designated HPW2, will follow the same progression of laboratory testing, TTC service testing, and revenue service testing.

REFERENCES

1. Jones, Kerry. "Interim Report: Comparison of AAR Class C and High Performance Wheels." *Technology Digest* TD-15-032. AAR/TTCI, Pueblo, Colorado, October 2015.

2. Hernandez, Francisco C. Robles, Semih Kalay, and Scott Cummings. "Properties and Microstructure of High Performance Wheels." *Technology Digest* TD-09-001. AAR/TTCI, Pueblo, Colorado, January 2009.

3. Cummings, Scott. "High Performance Wheel Test: 223,000-mile Interim Results." *Technology Digest* TD-12-024. AAR/TTCI, Pueblo, Colorado, November 2012.