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High Performance Wheel Test: 270,000-Mile Interim Results

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Summary

High performance wheels are being evaluated by Transportation Technology Center, Inc. (TTCI) at the Facility for Accelerated Service Testing (FAST), Pueblo, Colorado, and in revenue service as part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program to prevent wheel failures. The objective is to improve wheel wear and fatigue performance.

Four wheel types experienced shattered rims during the durability test at FAST. Subsequently, the wheel types were removed from the revenue service test as a precaution. No shattered rims have been found in the revenue service test. Types 1, 2, 5, and 7 remain in the revenue service test.

In total, only 12 AAR Class C and 6 high performance wheelsets have been removed for high impacts or shelling. Wheel spalling is not indicative of wheel performance, so removals due to spalling are not counted as performance failures. Other wheelsets have been removed for mechanical problems or reasons other than wheel performance and are not counted as wheel performance failures. TTCI personnel have conducted visual inspections of 46 percent of the remaining test wheels after approximately 270,000 miles of revenue service. No condemnable wheels have been found during these inspections.

The high performance wheels are performing better than the AAR Class C wheels in terms of both rolling contact fatigue and shelling. Statistical analysis of the limited data to date predicts that the high performance wheels will experience a 34 to 39 percent increase in service miles to removal compared to the Class C wheels.

Overall, the Class C and high performance wheels have accumulated an average of 270,000 miles, but some have exceeded 350,000 miles. Wheelset removals have not followed a seasonal pattern; only two wheelsets have been removed for cause in January. Most of the removals have occurred between May and November.

Monitoring of in-service wheel performance continues, and TTCI will inspect all wheels during 2015. The test is scheduled to conclude at the end of 2015. At that time, further revenue service testing of the "best performers" may be performed in a different service environment.

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INTRODUCTION

As part of the AAR's Strategic Research Initiatives Program to prevent wheel failures, a revenue service test is being conducted on six types of high performance wheels. The objective is to develop and demonstrate the benefits of high performance wheel steels, specifically focusing on improvements in resistance to wear and fatigue. The revenue service test is designed to quantify the benefits of each type of high performance wheel in comparison to the current standard AAR Class C wheels.

In addition to the revenue service test, a durability test is being conducted at Transportation Technology Center (TTC), Pueblo, Colorado, on a smaller sample of each type of wheel. The operating conditions of the durability test are intended to accelerate wear and fatigue damage on the wheels.

Standard Steel, Valdunes, Griffin, and Sumitomo donated high performance wheels for the project. A generic naming convention is used here to identify each manufacturer's wheels.

BACKGROUND

Testing of the high performance wheels is being conducted in three phases, which overlap to some degree. First, laboratory testing was conducted on each wheel steel including measurements of mechanical properties, microcleanliness, and residual stresses.[1] A microstructure evaluation determined that eight of the nine high performance wheel types were comprised of a pearlitic microstructure, similar to AAR Class C; Type 6 was the exception and was comprised of a bainitic microstructure. Next, the wheels were installed in loaded cars at TTC and subjected to a drag braking test and are currently involved in a durability test at FAST.[2] The third phase of testing for the high performance wheels is the revenue service test, which began in August 2009.[3] None of the testing completed to date has indicated any safety concerns related to the high performance wheels.

Steel hopper cars built in the early 1980s and owned by the Union Pacific (UP) Railroad are being used in the revenue service test of the high performance wheels. The empty weight of these cars is in the range of 61,000 pounds to 65,000 pounds, and the cars are rated for a gross rail load of 286,000 pounds. Immediately prior to the test, the cars went through a rebuild program, including a truck upgrade to AAR M-976 qualified trucks and long travel constant-contact side bearings.

High friction composition brake shoes (abbreviated as CMP) were installed on all cars equipped with the high performance wheels and on 16 control cars with AAR Class C wheels. During the rebuild in 2009, an additional 18 cars were equipped with AAR Class C wheels and one of two types of tread conditioning shoes (called TC-A and TC-B in this *Technology Digest*). This was done to compare the life of high performance wheels not only to that of AAR Class C wheels with composition brake shoes, but also to the wheel life of AAR Class C wheels with tread conditioning brake shoes. Tread conditioning brake shoes were not paired with any of the high performance wheels to maximize the sample size of the high performance wheels paired with composition brake shoes. Stencils on each test car indicate which shoe type to apply when the shoes are in need of replacement. Additional details regarding the initial test conditions and the test plan have been reported previously.[3] In 2011, UP replaced all of the TC-B brake shoes with TC-A brake shoes and updated the stencils on the cars to indicate this change.

INSPECTION PROCEDURES

After 270,000 miles of accumulated revenue service, TTCI personnel visually inspected 46 percent of the wheels in the revenue service test without removing the wheels from the cars. The majority of the wheel tread surface was viewed, excluding where the rail or the brake shoe blocked access to the tread. The inspectors were specifically looking for scuffing-related tread damage, shells, and spalling.

Because spalling results from wheel slip or wheel slide, it is not reflective of the performance of the wheel. Thus, wheels with spalling damage were excluded from further analysis. Wheel profile measurements were taken for nearly all of the wheels. In the most recent inspection, ultrasonic testing was performed on the tread of each wheel to search for delamination or other indications. Expanded measurements of scuffing-related crack bands and shelling locations were also recorded.

Post inspection review of the notes and photographs were used to determine whether the damage on a wheel tread was the result of spalling or shelling.

REVENUE SERVICE TEST RESULTS

There are 102 Class C wheelsets and 93 high performance wheelsets remaining in the test. About half of the cars that started in the test have been pulled out for various reasons, but only 20 wheelsets have been pulled out for shelling or high impacts. The cars are scattered among different trains, appearing in groups of two or three in a given train. Because of this scattering, inspection requires multiple visits to multiple locations.

Several types of features have been noticed on the test wheels. Figure 1 shows shelling outside of the tape line. None of the wheels inspected had shells large enough to be deemed condemnable under AAR rules. Scuffing-related cracks are shown in Figure 2 and occur in about half of the wheels observed. Material frequently breaks out along these crack bands. Over time, if enough material from shells or crack bands breaks out, high impacts will result. This is the primary cause for removal for the test wheels.

Table 1 shows the wheelset information for each wheel type remaining in the revenue service test. No Type 2 wheels have been removed for cause. Six high performance wheels have been removed for cause compared to 12 Class C wheels. The bottom two rows of this table represent the totals of the high performance wheels (Types 1, 2, 5, and 7), and the Class C wheels (Types CMP and TC-A), respectively.

Figure 1. Shelling on a Wheel in the Revenue Service Test

Figure 2. Scuffing-Related Tread Damage on a Test Wheel

No shattered rims have occurred in the revenue service test. Some wheels have material loss along crack bands or shelling, but very few have experienced high impacts. Five types of high performance wheels experienced shattered rims at FAST and were subsequently removed from the revenue service test as a precaution. No shattered rims have occurred in the revenue service test.

Table 1. Wheelset Information for Revenue Service Test

Wheel Type	Initial Sets	Removed for Cause	Active Sets Remaining	Average Active Miles
1	29	1	27	276,000
2	28	0	27	277,000
5	25	2	20	274,000
7	25	5	19	263,000
CMP	54	8	38	255,000
TC-A	72	4	64	266,000
HPW*	107	8	93	273,000
Class C	126	12	102	262,000

*HPW = high performance wheels

Figure 3 shows the distribution of high impact or shelling removals in this test, beginning in 2009 to late 2014. Two Class C wheelsets were removed in November and two in January, but the majority of removals have occurred between May and October. Snow and water will penetrate into cracks or voids in the steel. The expansion of water during freezing causes cracks to expand; when the force exerted by the ice exceeds the tensile strength of the steel, pieces of the tread will fall away from the wheel. In this case, winter conditions have not directly led to rapid shelling.

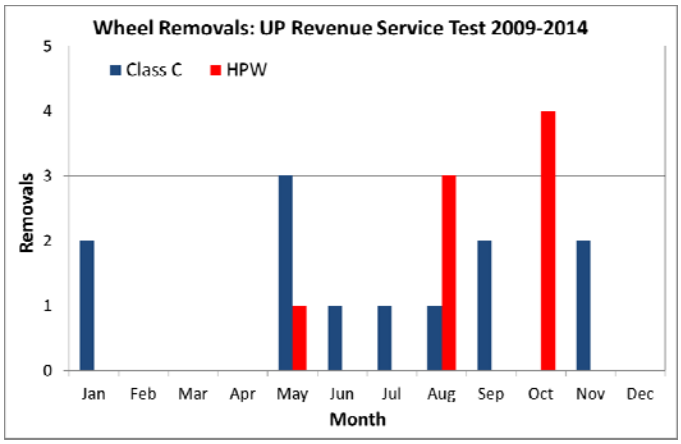

Figure 3. Wheel Removals Listed by Month

Figure 4 shows the Weibull probability plot for Class C versus high performance wheels. With the few failures that have occurred during this test, life prediction of the high performance wheels becomes difficult because of large spread in the confidence intervals. Analysis of current data indicates the high performance wheels are expected to have a 34 to 39 percent higher mean time to failure than Class C wheels. Figure 5 shows a similar plot for the two types of Class C wheels, but predicts very similar life for both types of Class C wheels.

Figure 6 shows the distribution of mileages in the wheelsets. Note that some wheels exceed 350,000 miles.

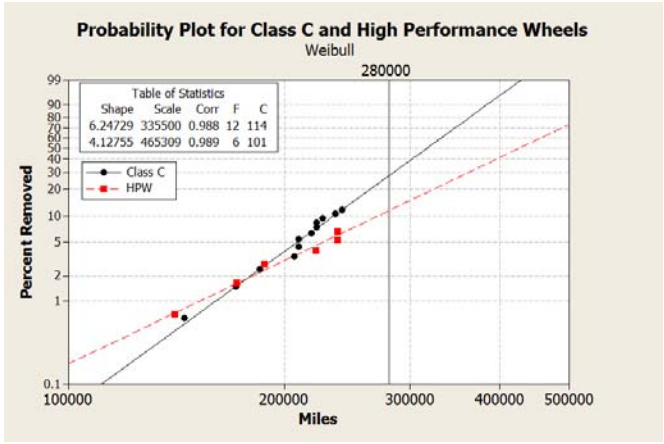

Figure 4. Probability Plot for Class C and High Performance Wheels in the Revenue Service Test

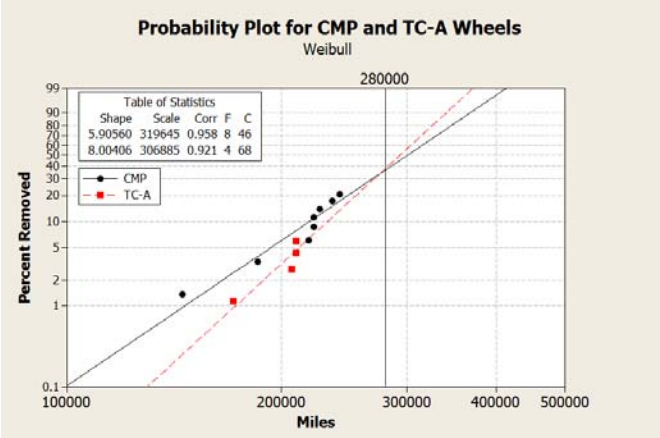

Figure 5. Probability Plot for CMP and TC-A Wheels

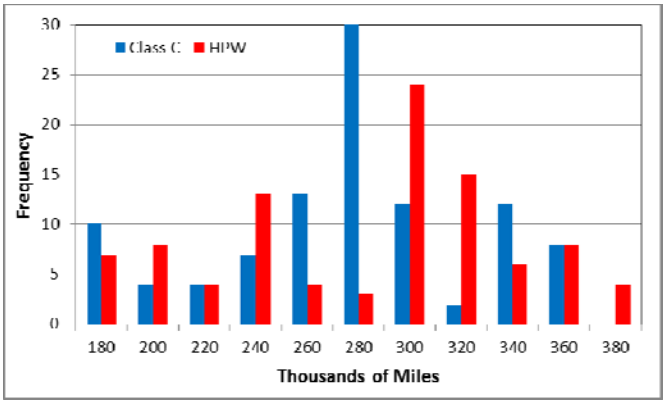

Figure 6. Mileage Distribution of Active Wheelsets

CONCLUSIONS

Inspection of almost half of the wheels involved in the revenue service high performance wheel test after 270,000 miles showed that most wheels are still in good condition and very few have been removed for cause. The high performance wheels show improved performance compared to AAR Class C wheels in terms of removals and shelling. Based on current data, the high performance wheels are predicted to last 34 to 39 percent longer than standard Class C wheels.

In 2015, TTCI inspectors will attempt to inspect all of the cars again. UP will continue to provide mileage, repair, and removal data.

ACKNOWLEDGEMENTS

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