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Revenue Service Test of High Performance Wheels: 23,000-Mile Interim Results

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Summary

Eight types of high performance wheels are being evaluated by Transportation Technology Center, Inc. (TTCI) in a revenue service Union Pacific coal train as part of the Association of American Railroads' (AAR) Strategic Research Initiatives (SRI) Program to prevent wheel failures.

The wheels were generally in good condition; however, at least one wheel of each type had some degree of minor shelling with the exception of the bainitic wheels (type 6) which did not show any shelling. At this early stage in the test, Class C wheels with composition brake shoes are performing as well as most of the high performance wheel types and the average wear rate of the different wheel types is similar. Class C wheels with tread conditioning brake shoe type B are showing more rolling contact fatigue cracks and shelling compared to all other wheel and brake shoe combinations.

The goal of this SRI is to develop and test high performance wheels to improve the wear and fatigue performance. A revenue service test was initiated in 2009 to quantify the benefits of eight types of high performance wheels paired with composition brake shoes in comparison to AAR Class C wheels paired with composition brake shoes and two types of tread conditioning brake shoes.

TTCI personnel conducted visual inspections of most of the test wheels after approximately 23,000 miles of revenue service. Shells and spalls were further investigated with etchant and surface hardness readings. Wheel profiles were measured on a representative sample of wheels. The train has since been rerouted into a service where it should accumulate mileage at a higher rate.

Griffin, Lucchini, OneSteel, Standard Steel, Sumitomo, and Valdunes donated high performance wheels for this project. OneSteel is participating with two steel compositions. The SRI steel wheel is also being tested as part of this program.

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INTRODUCTION

As part of the AAR's SRI program to prevent wheel failures, a revenue service test is being conducted on eight types of high performance wheels. The goal of this project 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 being conducted to quantify the benefits of each type of high performance wheel in comparison to the current standard AAR Class C wheels.

Griffin, Lucchini, OneSteel, Standard Steel, Sumitomo and Valdunes donated high performance wheels for this project. OneSteel is participating with two steel compositions. TTCI's high performance wheel, known as the SRI wheel, is also being tested. With the exception of the SRI wheel, a generic naming convention will be used to identify each manufacturer's wheels.

BACKGROUND

The testing of the high performance wheels consists of three overlapping phases. First, laboratory testing was conducted on each wheel steel including measurements of mechanical properties, microcleanliness, and residual stresses.[1,2,3] Next, the wheels were installed in loaded cars at the Transportation Technology Center, Pueblo, Colorado, and subjected to a drag braking test and are currently involved in a durability test at the Facility for Accelerated Service Testing.[4,5] None of the testing completed to date has indicated any safety concerns related to the high performance wheels. The third phase of testing for the high performance wheels is the revenue service test that began in August 2009.

Steel hopper cars owned by Union Pacific (UP) are being used in the revenue service test of the high performance wheels. The light 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. Build dates on the cars range from 1979 through 1983.

Immediately prior to the test, the cars went through a rebuild program consisting of a truck upgrade to AAR M-976 qualified Barber S2-HD-9C split wedge trucks with primary suspension shear pads and D5 spring nest. The height of the sides and ends of the cars was extended to increase the cubic capacity to 4,000 cubic feet. The cars were equipped with polymer center-bowl liners and long-travel constant-contact side bearings with a nominal 6,000-pound preload. The brake arrangement is a body-mounted rod-through-bolster design with the dead levers connected to the bolsters. Slope sheet empty/load devices provide a 50-percent reduction in brake cylinder pressure when the cars are empty.

High friction composition brake shoes were installed on all cars equipped with the high performance wheels and 16 control cars with AAR Class C wheels. 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 report). This was done in order 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.[6]

INSPECTION PROCEDURE

TTCI personnel visually inspected a total of 630 wheels from the test train 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. An average of approximately 1 minute and 15 seconds was spent visually inspecting each wheel. The inspectors were specifically looking for rolling contact fatigue (RCF cracks, shells/spalls), and any indications of wheel sliding. When the visual inspectors identified shells or spalls on a particular wheel, a nondestructive testing technician documented the condition by applying etchant to look for martensite and performing a series of surface hardness tests near the affected area. Post inspection review of the notes, photographs, etching results, and hardness values were used to determine whether the damage on a wheel tread was the result of a sliding event (spalling) or fatigue (shelling).

Wheel profiles were hand measured on 116 wheels using a wheel Miniprof™. Typically, the four wheels on one side of a car were measured to maximize the sample size in the allotted inspection time of the assembled train.

While the cars in the test train have largely stayed together, not all of the cars with test wheels were present at the inspection site. Accordingly, not every wheel in the test was inspected.

RESULTS

A wheel slide event that results in a spall is not reflective of the performance of the wheel. Thus, wheels with spalling damage were excluded from further analysis. Figure 1 shows an example of a spalled wheel seen during the inspection.

Wheels without spalls were placed into one of three possible categories: RCF cracks, shells, or good. Wheels in the RCF crack category did not have shells. Wheels in the shells category may or may not have also had RCF cracks. Wheels in the good category had no visible indications of RCF cracks or shells. Table 1 is a categorized summary of the wheel tread conditions. Figure 2 shows the categorized percentages of unspalled wheels per wheel type. None of the wheels inspected had damage that would be deemed condemnable under AAR rules.

Figure 3 shows an example of a wheel with shells seen during the inspection.

Figure 1. Wheel with Spalls

Table 1. Inspection Results

Wheel Type	Profile Wheel Count	Inspected Wheel Count	Spalled Wheel Count	Unspalled Wheel Count	RCF Cracks Wheel Count	Shells Wheel Count	Good Wheel Count
1	8	58	0	58	0	5	53
2	12	56	0	56	0	1	55
3	4	50	0	50	0	5	45
4	10	52	2	50	0	2	48
5	8	50	8	42	1	2	39
6	14	52	0	52	0	0	52
7	9	50	0	50	1	7	42
SRI	8	26	2	24	0	1	23
C, Cmp	19	100	2	98	0	6	92
C, TC-A	12	80	0	80	3	7	70
C, TC-B	12	56	0	56	9	13	34

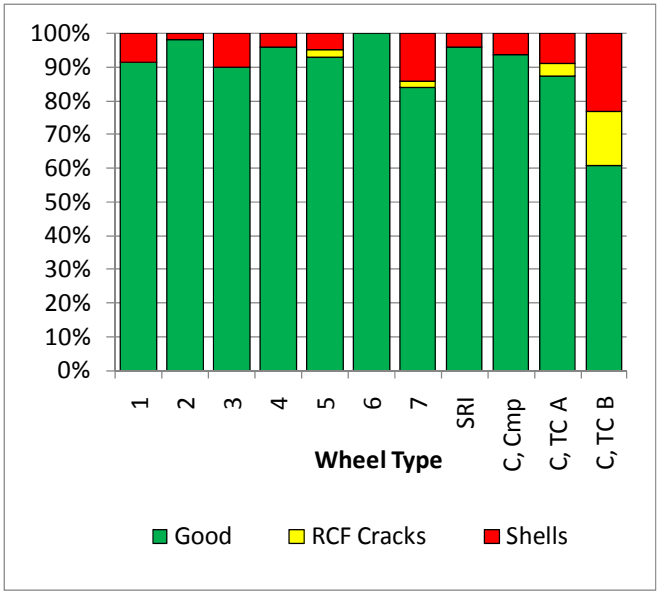

Figure 2. Tread Condition

Figure 3. Wheel with Small Shells

Wheel profiles measured during the inspection were compared to the wheel profiles from the same wheels measured before initiation of the revenue service test in August 2009. In this manner, a wear value of the flange width and flange height was established for each wheel

measured during the inspection. Figure 4 shows the average wear of the flange width and flange height for the sample of wheels measured during the inspection, categorized by wheel type. As shown, the flange width is wearing more quickly than the tread (as indicated by the flange height) for the wheels in the revenue service test. This result is consistent with other studies that have found high initial flange width wear rates for wheels with AAR-1B profiles in revenue service due to poor conformality with typical worn rail profiles.[7] At this early stage of the test, all wheel types are showing similar wear rates.

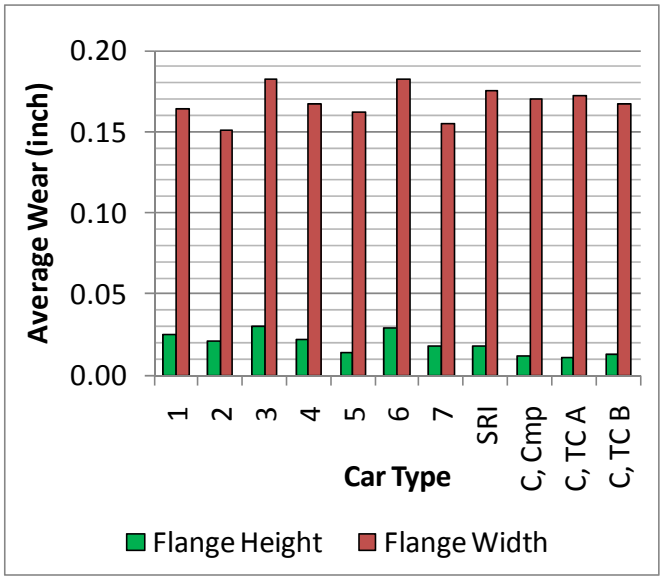

Figure 4. Wheel Wear

WAYSIDE DETECTOR DATA

The test train was run through the UP cracked wheel detector in North Platte, Nebraska, in December 2009. The ultrasonic scanners did not indicate internal defects in any of the wheels.

Data from a wayside wheel profile detector recorded in December 2009 showed similar wear levels on all of the wheel types.

Limited wheel impact load detector (WILD) data from the test cars shows minimal problems with impact loads. One type 4 wheel is showing impact loads exceeding 60,000 pounds and dynamic loads exceeding 30,000 pounds. This car was not present at the inspection site, and thus the wheels were not inspected.

TRAIN ROUTING

As a revenue earning train for the UP, the routing is subject to changes periodically throughout the course of this test. The majority of the test to date has been run on a low mileage route between Utah and California with a brief excursion into Powder River Basin service. In an effort to increase the rate of mileage accumulation, the UP has recently rerouted the train to a higher mileage service between Colorado and Kentucky. The new route also contains WILD sites, allowing for more regular assessment of the wheel impact status.

CONCLUSION

An inspection of the majority of the wheels involved in the revenue service high performance wheel test after 23,000 miles revealed the following:

- None of the bainitic wheels (type 6) inspected showed any signs of RCF cracks or shelling.
- At least one wheel of each of the other wheel types in the test had some degree of minor shelling.
- The average wear rate of the different wheel types is similar.
- At this early stage in the test, Class C wheels with composition brake shoes are generally performing as well as most of the high performance wheel types.
- Class C wheels with tread conditioning brake shoe type B are showing more RCF cracks and shelling compared to all other wheel and brake shoe combinations.

ACKNOWLEDGEMENTS

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