

The research described was performed by Transportation Technology Center, Inc., a wholly owned subsidiary of the Association of American Railroads.

## Performance of Reconditioned Bearings with Cup Spalls: Phase 1

Dustin Clasby and Steven Belport

### Key Findings:

- All 12 test bearings produced temperature and vibration signatures within normal operational experience both before and after reconditioning repairs.
- A spall was found to have developed in the immediate vicinity of the repaired area of one of the bearing cups just 8,700 miles after reconditioning. This development highlights the need for life-expectancy testing of reconditioning repairs as planned in Phase 2.

[TTCI](#) is undertaking research to investigate the performance and service life of reconditioned bearings. The reconditioning of bearings is a common practice in the railroad industry, with 90 percent of bearings in revenue service having been through a reconditioning process. This process is undertaken every time a bearing is removed from its axle and involves disassembly, inspection, repair (if needed), and reassembly.

The testing of repaired reconditioned bearings for this research project is comprised of two testing phases. Phase 1 focuses on evaluating any changes to the operating temperature and vibration of the bearing shortly before and after the reconditioning process, while Phase 2 will explore the expected service life of repaired defects. The testing method of Phase 1 was to establish a baseline for comparing bearing performance before and after reconditioning repair using approximately 10,000-mile runs on a test rig at the University of Texas Rio Grande Valley (UTRGV). These relatively short test runs allow the bearings to reach a steady-state in operational performance metrics. This *Technology Digest* presents the results from Phase 1 only; activities for Phase 2 are currently underway.

For this performance test, TTCI investigated bearings with raceway spalling—the most common type of defect per AAR Roller Bearing Reports (MD-11) records. The reconditioning process for spalls begins with a visual inspection of the raceway. If any defect is identified, and by AAR rules, is capable of being repaired, it is ground out with a hand-held rotary tool to remove stress points, leaving a cavity in the raceway. Phase 1 testing investigated whether the raceway cavities created during the spall repair process could cause bearing performance issues that could trigger alarms from wayside bearing detectors.

### TEST SETUP

As bearings are pulled from revenue service for reconditioning, they are disassembled and visually inspected. Defects that meet the AAR standards are repaired, and the bearings are re-assembled to return to revenue service. Bearings with spalls can be returned to service if the repair is smaller than 3/8 inch in diameter and less than 1/8 inch deep.<sup>1</sup>

The Phase 1 test was comprised of 12 bearings identified through the inspection process as having spalls that were then re-assembled without repair. After initial baseline performance tests of vibration and temperature, these bearings were sent for reconditioning repair at a designated facility chosen by TTCI. The bearings were then re-tested after the spalls were ground out. The same bearing components were used for each test bearing prior to and after reconditioning repair. Each test bearing was freshly greased prior to each performance test. Figure 1 shows one of raceways before and after reconditioning.

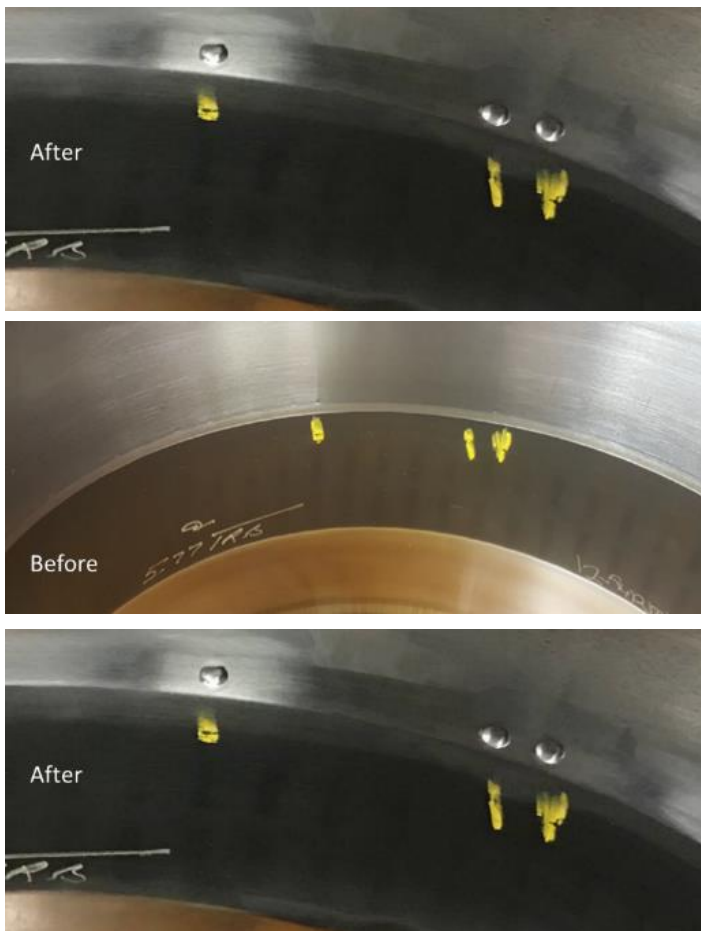


Figure 1. Before and after reconditioning spalls on bearing raceway

Figure 2 shows UTRGV's four-bearing tester (4BT), and Figure 3 shows the arrangement of the transducers.<sup>2</sup> Bearings were tested in pairs in the two central positions of the axle. The two bearings mounted on the outermost positions of the axle were not considered part of the test. Temperature and vibration data were recorded for each test bearing. The middle two bearing adapters were machined to accept:

- Two 70g accelerometers placed in the outboard Smart Adapter (SA) and Mote (M) locations.
- Two K-type bayonet thermocouples and one regular K-type thermocouple aligned with the two bayonet thermocouples and placed midway along the bearing cup width.

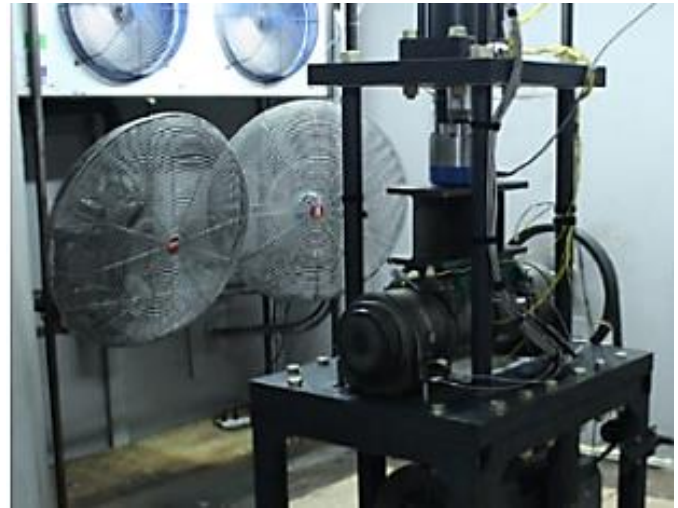


Figure 2. Four-bearing testing rig (4BT)

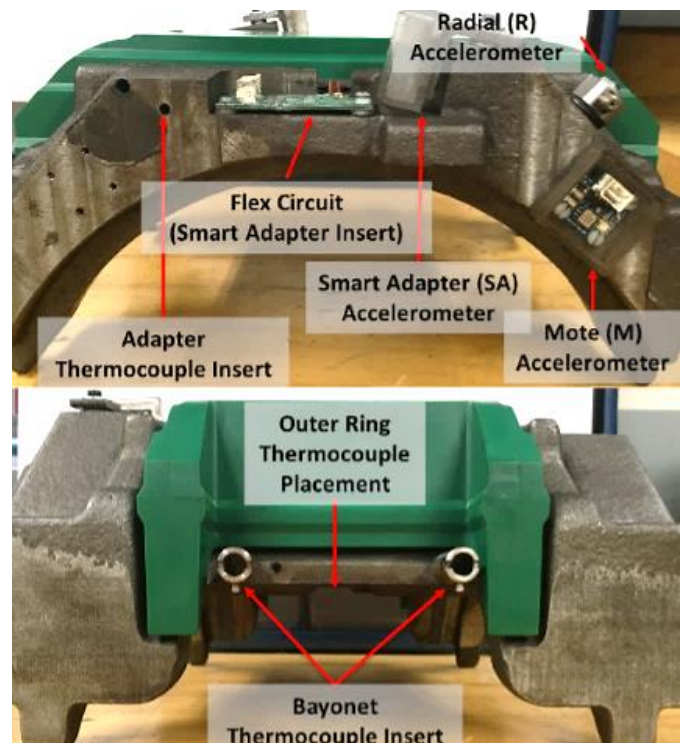


Figure 3. Modified bearing adapter showing transducer locations

The data provided from these tests were collected using two load and speed conditions. First, 17 percent of full load

(representing an empty railcar) at an equivalent train speed of 53 mph was used only at the beginning of each test to allow for a break-in period for the bearing grease. Second, 100 percent of full load (full load is equal to 34.4 kips per Class K bearing) at an equivalent train speed of 85 mph was used for the remainder of the test.<sup>2</sup>

## TEST EXPERIMENTS

### Pre-reconditioning Repair

As stated, all 12 bearings were tested before repair. Tests of the first two bearings, Bearing 1 and Bearing 2, are explained in detail below, and the subsequent bearing runs are summarized. After the pre-reconditioning repair test runs of Bearings 1 and 2, the vibration and temperature profiles were analyzed. This analysis provided a baseline for comparison to the bearings' performance after reconditioning repair. With regard to temperature, both bearings were operating below the average normal operating temperature for control bearings as determined by UTRGV personnel, except for the initial break-in period of the grease and the period immediately following sudden changes in operating conditions (start and stop of the testing rig). Bearing 2 ran slightly hotter than Bearing 1 by about 20°F throughout the experiment.<sup>2</sup>

With regard to vibration, Bearing 2 ran with slightly higher overall vibration levels than Bearing 1 throughout the testing period. Bearing 2 also exhibited some erratic vibration behavior throughout the entire experiment.<sup>2</sup>

### Post-reconditioning Repair

After the baseline testing of the pre-reconditioning repair, the bearings were sent to a designated facility for reconditioning repairs.

The repair of a raceway spall is completed by removing material around the spall with the intent of removing the visible defect and alleviating stress points that could have lead to further degradation of the raceway steel.

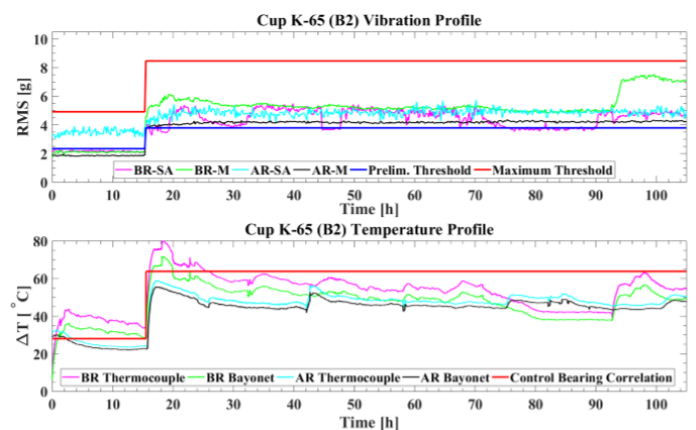
After reconditioning repair, Bearings 1 and 2 were setup on the test axle using the same configuration and bearing cup orientation used during the pre-reconditioning test. This test setup was done to allow for a direct comparison of the vibration and temperature profiles pre- and post-reconditioning repair. The test bearings ran a total of 13,611 miles after the repair.<sup>2</sup> This distance was enough for the bearings to arrive at a steady

state in temperature and vibration performance to satisfy the requirements of the first test phase.

Upon analyzing the temperature profile, it was observed that the operating temperature of Bearing 1 after reconditioning was more stable and generally lower after the reconditioning process compared to before reconditioning.<sup>2</sup>

The vibration levels after the reconditioning process for Bearing 1 were similar to those before this bearing was repaired. Overall, the reconditioning process stabilized and slightly improved the operating temperature of Bearing 1 but did not significantly affect the vibration levels within the bearing.

Figure 4 shows the vibration and temperature profiles for Test Bearing 2.<sup>2</sup> The solid red line in these charts indicates a threshold of poor performance used by UTRGV based on historical bearing tests. The solid blue line in the vibration chart is the average value for new bearings tested by UTRGV.



**Figure 4. Vibration and temperature profiles for test Bearing 2 before and after the reconditioning process**

Observation of the temperature profiles for Test Bearing 2 before and after reconditioning repair showed that the reconditioning process helped stabilize and noticeably lower the operating temperature of this bearing. Comparing the vibration profiles for Bearing 2 before and after reconditioning repair, the vibration levels after repair are more stable and slightly lower than before repair where the vibration levels exhibit some distinct fluctuations. Hence, the reconditioning process improved the overall temperature and vibration performance of Test Bearing 2 more so than it did for Test Bearing 1.<sup>2</sup>

The remaining 10 bearings were tested in the same manner. Tests were continued for each pair of test bearings

until steady state conditions were achieved. Table 1 provides the mileage and results of these tests.

**Table 1. Testing results**

ID	Pre-repair Test Mileage	Post-repair Test Mileage	Effect of Repair on Temperature	Effect of Repair on Vibration
1	16,998	13,611	Decreased and less variation	No change in the vibration levels
2	16,998	13,611	Decreased and less variation	Decreased slightly
3	6,541	8,700	No change in the operating temperature	Decreased slightly
4	6,541	8,700	Decreased slightly	Decreased slightly
5	6,270	12,540	No change in the operating temperature	Decreased
6	6,270	12,540	Decreased	Decreased
7	9,791	10,001	Increased slightly, but still within normal operation thresholds	Decreased slightly
8	9,791	10,001	Decreased and less variation	Decreased
9	8,098	16,198	Increased slightly, but still within normal operation thresholds	Decreased
10	8,098	16,198	No change in the operating temperature	No change in vibration levels
11	8,554	12,135	No change in the operating temperature	Decreased slightly
12	8,554	12,135	Operating temperature increased, but still within normal operation thresholds	Decreased slightly

The performance of all 12 bearings during the pre-reconditioning repair portion of the test was deemed to be within the normal operating threshold. Despite these bearing cups having spalls, it is not surprising that they exhibited normal temperature and vibration performance before reconditioning because spalls that are allowed to be repaired are quite small.

Although the temperature and vibration measurements for Test Bearing 3 generally looked good during the post-reconditioning repair testing, a spall on one of the cup raceways was noted after running 8,700 miles post-

reconditioning repair. The spall initiated near the stress-relief holes created during the repair process. As stated, Phase 2 of this research project will explore the expected life cycle of reconditioned bearings and attempt to determine whether this re-developed spall was a spurious result or a concern for the reconditioning process.

### CONCLUSION

Overall, the results suggest that spall repairs during the reconditioning process did not have a major effect on the short-term performance of the test bearings. Of the 12 bearing cups tested, all produced temperature and vibration signatures within normal operational experience both before and after reconditioning repairs. Five test bearings experienced more steady temperatures or lower operating temperatures after the reconditioning process. Ten of the bearings experienced a decrease in the vibration levels during operation after the reconditioning process. The next phase of testing will test for the life expectancy of reconditioning repairs to determine how long a spall repair could be expected to last in revenue service. The importance of this next phase of testing was illustrated by the early re-appearance of a spall in Test Bearing 3.

### References

1. *Manual of Standards and Recommended Practices*, Section H-II, Roller Bearing Manual, S-721 Mandatory Instructions and Practices, AAR, 2017, Washington, DC.
2. Hernandez, V., Arroyo, J. Tarawneh, C. 2019. "Evaluating the Thermal and Mechanical Performance of Reconditioned Railroad Tapered-Roller Bearings" University of Texas-Rio Grande Valley, Edinburg, TX.

**For comments or questions about this publication, contact [Dustin Clasby@aar.com](mailto:Dustin.Clasby@aar.com)**

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