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Temperature Differences for Bearings in Lead and Trailing Positions Measured with Two Scan Distances

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Summary

Transportation Technology Center, Inc. (TTCI) analyzed the difference in bearing temperatures between bearings in the lead and trailing positions, and in the same load condition, at two test sites provided by Union Pacific Railroad and CSX Transportation. The test sites included the traditional 7 1/4-inch and the proposed 9-inch (under test) scan distances. The analysis of revenue service hot bearing detector (HBD) data for the available cars did not show a benefit of the 9-inch scan distance for the circumstances studied.

The analysis focused on freight equipment with sufficient passes including gondolas, hoppers, and intermodal low-profile and stack cars.

All traditional HBD show differences between lead and trail measurements. The 9-inch scan configuration is worse than the 7 1/4-inch scan configuration due to more blockage. The two test sites indicate increases in temperature differences for the 9-inch compared to the 7 1/4-inch scan distance:

- Site 1 with empty gondola and hopper cars shows 2 to 10 times more cars with temperature differences for 9-inch scan distance than for 7 1/4-inch scan distance.
 - Temperature differences for the 9-inch scan distance tend to be higher.
- Site 2 with loaded intermodal cars has about two times more cars with temperature differences for 9-inch scan distance than for 7 1/4-inch scan distance. Loaded hopper cars have a high number of differences for both 7 1/4-inch and 9-inch scan distances.
 - There are more bearings with temperature differences for 9-inch scan distance, but the average temperature differences are similar for 7 1/4-inch and 9-inch scan distances.

Additional work in 2017 examined the false positive and negative rates of the 9-inch compared to the 7 1/4-inch scan distances including 3-D models of several trucks to measure the effect of blockage and to compare the temperatures from 7 1/4-inch and 9-inch scan distances with new multiple-scan HBD technology. The analysis of revenue service HBD data for the available cars did not show a benefit of the 9-inch scan distance for the circumstances studied.



INTRODUCTION

In 2013 and 2014, (Phase I and II) testing was conducted at Transportation Technology Center (TTC) on the Railroad Test Track (RTT) using detectors provided by vendors or railroads to study various hot bearing detector (HBD) technologies to assess railcar bearing health.¹ A total of 16 configurations of HBDs were evaluated and rank ordered in Table 1. The current HBD technology used by the North American railroad industry was tested with different scan distances towards the center of the bearing.

Table 1. Rank Ordered Effectiveness (lower nominal ranking better)

Technology	Distance from Rail Gage Point (inch)	Nominal Ranking
Multiple scan Vertical	Various	2.1
Single scan Vertical	9.50	2.8
Single scan 45 degrees	9.00	4.0
Single scan 45 degrees	8.25 - 8.50	4.1
Single scan 45 degrees	9.50 - 11.25	4.5
Single scan 45 degrees	14.00 (current)	5.0
Single scan 45 degrees	7.25 (current)	5.0

Traditional HBDs scan a single small area by viewing 45 degrees upward from horizontal as the bearing moves past, inboard at 7 1/4 inches from the rail gage point² (Figure 1). With normal lateral movement of the wheelset, this scan may view the backing ring on one pass, the cup edge on another, and the seal on other passes. The 7 1/4-inch (inboard of bearing race) and 14-inch (outboard of bearing race) scan distances are the predominant technologies currently in use in North America.

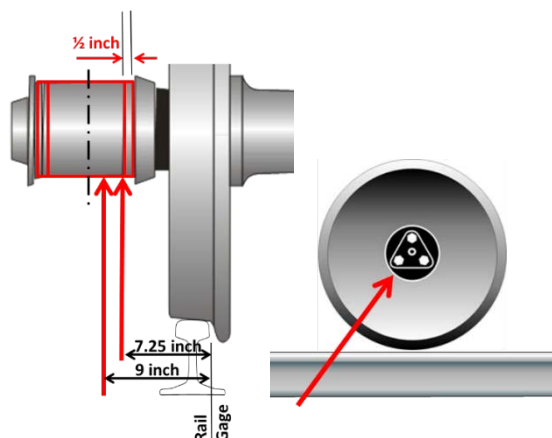


Figure 1. Scan position of tested HBDs

Several railroads selected 9-inch scan distance for collocated testing based upon the rank ordered improvement over current 7 1/4-inch or 14-inch scan distances from the 2013 and 2014 testing.

Truck components including side frames, frame keys and frame brace mounts, can potentially interfere with temperature measurements. CSX Transportation and Union Pacific Railroad provided data from test sites that include detectors at 7 1/4- and 9-inch scan distances. An analysis of the temperatures standardized to specific bearings was performed to measure the effects of a car facing the same direction and moving east and west (or north and south) at a detector site. The objective is to identify a bearing technology that performs better than the existing 7 1/4-inch scan distance in use.

ANALYSIS

This analysis examined the temperatures of many bearings at each of the sites. Each bearing was compared with the following conditions to reduce variation in the analysis.

- Each car was examined at one site in the same orientation
- The car had to travel in both directions in one orientation so that each bearing was measured by the same HBD
- A minimum of three detector passes were required in both of the lead and trailing positions
- The load condition of the car had to be the same for the detector passes in the lead and trailing positions

When a bearing was in the lead position (first axle of a truck), the lead part of the side frame may have obstructed the beam of the 7 1/4- or 9-inch HBD, as shown in the highlighted area in Figure 2. A bearing in the trailing position (rear axle of truck), see highlighted area in Figure 3, may have been obstructed by a larger portion of the side frame as well as a frame key or frame brace mount if present (not shown) for the 7 1/4- or 9-inch HBD.

Larger blockage will cause a greater difference in temperature measurements. An ideal system would have no difference between leading and trailing positions.

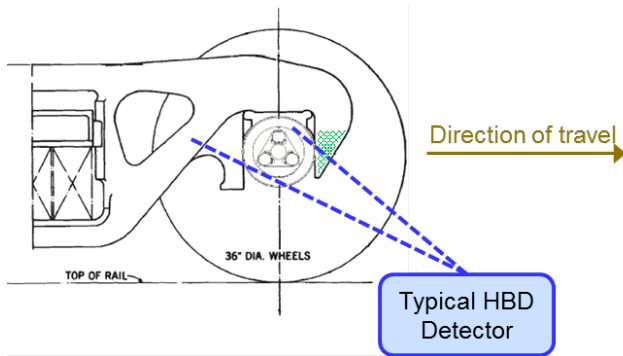


Figure 2. Approach of bearing to HBD in lead position

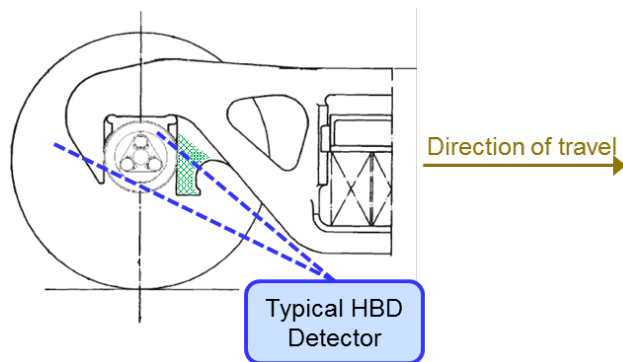


Figure 3. Approach of bearing to HBD in trailing position

The load condition was determined using Wheel Impact Load Detectors (WILD). HBD detector passes were included where the car passed by a WILD site within 36 hours. The 4-axle freight cars were considered loaded or empty and multi-platform intermodal cars were considered empty to lightly loaded (empty) or medium to fully loaded (loaded).

The statistical analysis was performed with the 2-sample t hypothesis test to measure differences between the temperatures in the lead and trailing positions for every included axle. Each bearing-car orientation pair was considered a separate analysis, so the left bearing on axle 1 (L1) was considered separate if the load condition, car orientation or detector site did not match. This was to assure that the analysis was completed with as few other factors as possible.

The detector test sites started with over 7.3 million bearing passes that were reduced to 138,804 unique bearing passes (1,299 unique cars) that met the conditions above. The 138,804 bearing passes included 17,288 unique bearing-car orientation pairs that came from the two test sites as follows:

- Site 1 included **empty** traffic with unequipped (H) and equipped hoppers (K) and rotary gondolas (J)
- Site 2 included **loaded** traffic with covered hoppers (C), low profile intermodal (Q) and stack cars (S)

Other types of traffic also passed at the test sites, but were excluded for insufficient data due to changing car orientations or load conditions.

RESULTS

The analysis examined two aspects of the lead and trailing differences; the percentage of bearings that have temperatures that are statistically different, and the amount of temperature differences, see Table 2.

Table 2. Percent Differences by Site and Car Type

Sites	Car Type	7 1/4-inch Percent	9-inch Percent	Bearing-Car Orientation Pairs
1	H	2.8%	29.1%	800
1	J	7.7%	18.9%	896
1	K	12.6%	26.4%	1,608
2	C	82.7%	80.4%	1,196
2	Q	12.2%	21.9%	8,852
2	S	8.1%	14.3%	3,176

For Site 1, while some of the bearings past the 7 1/4-inch detector had measurable temperature differences between the lead and trailing positions, those at the 9-inch detector had many more of the bearings affected. This means that there are some effects of moving the system to the 9-inch configuration, which create a larger difference between leading and trailing bearings. From other testing, the assumption is this effect is caused by blockage. For Site 2, the intermodal cars (Q & S) likewise had many more bearings with measurable temperature differences. The covered hoppers (C) at Site 2 had a high number of differences for both detectors.

Figures 4 and 5 show the temperature differences between the lead and trailing positions by site and car type. The charts show the number of bearings that have a temperature difference between the lead and trailing positions that includes only those bearings that are statistically different from Table 2. For Site 1, the temperature differences for the 9-inch scan distance (red) are noticeably higher than for the 7 1/4-inch (blue) scan distance. For Site 2, the temperature differences for the 7 1/4- and 9-inch scan distance mostly overlap and are about the same.

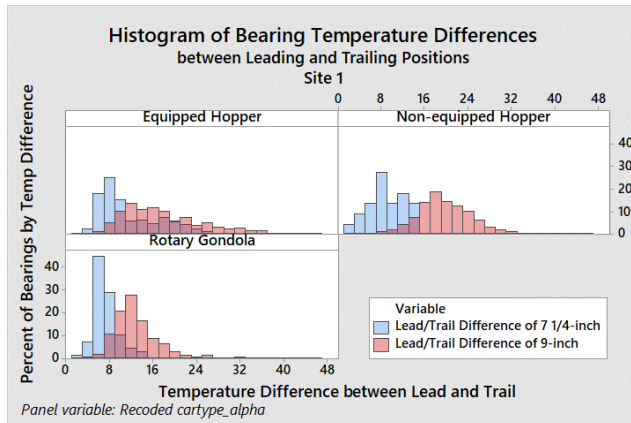


Figure 4. Site 1 Temperature Differences

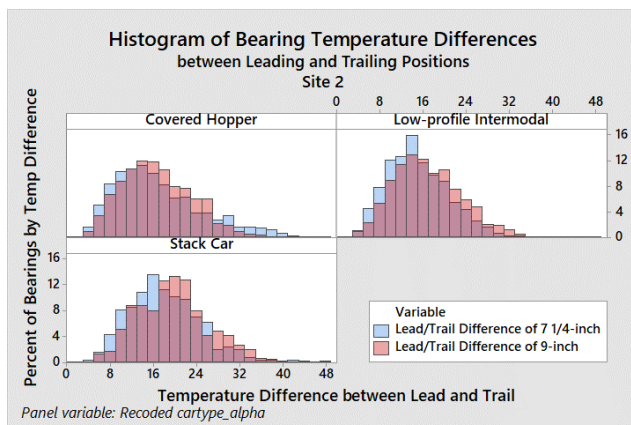


Figure 5. Site 2 Temperature Differences

CONCLUSION

The car types available at the two test sites show increases in the number of bearings with temperature differences between the lead and trailing positions for the 9-inch scan distance compared to the 7 1/4-inch scan distance, see Table 2:

- Site 1 cars showed 2 to 10 times more cars with temperature differences for the 9-inch scan distance than for the 7 1/4-inch scan distance.
- Site 2 cars had about two times more cars with temperature differences for 9-inch scan distance than for 7 1/4-inch scan distance. C car types had a high percentage for both scan distances.

The measureable differences in temperatures between the lead and trailing positions for the two sites performed differently, see Figure 4 and Figure 5.

- At Site 1, the temperature differences were much higher for the 9-inch scan distance
- At Site 2, the temperature differences were similar for 7 1/4- and 9-inch scan distances.

At Site 1, there was an increase in the number of bearings affected by their lead or trailing positions, and the temperature differences for the 9-inch scan distance were much greater than for the 7 1/4-inch scan distance. At Site 2, while there was an increase in the number of intermodal bearings affected by the 9-inch scan distance, the temperature differences were similar to the 7 1/4-inch scan distance.

The analysis of revenue service HBD data for the available cars did not show a benefit of the 9-inch scan distance for the circumstances studied. In conclusion, there is a decrease in consistent bearing measurements, an increase in difference between the leading and trailing bearings, using the 9-inch scan configuration as opposed to the 7 1/4-inch scan configuration.

NEXT STEPS

One railroad is installing a high precision device (multiple-scan vertical looking HBD) at a test site to determine false positive and false negative rates of the 9-inch compared to the 7 1/4-inch scan distances. A companion *Technology Digest* TD-17-007, *An Analysis of Obstruction of the Scan Area of HBDs with 3-D Modeling* contains studies of the effects of blockage from side frame, frame keys and frame brace mounts.³

ACKNOWLEDGEMENT

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References

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3. Carter, Daniel and Dustin Clasby. April 2017. "An Analysis of Obstruction of the Scan Area of HBDs with 3-D Modeling." *Technology Digest* TD-17-007. AAR/TTCI. Pueblo, CO.

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