U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 23-15 | **August** 2023

ANALYSIS OF TREAD BUILDUP ON RAILROAD WHEELS

SUMMARY

Tread buildup (TBU) is the formation of metallic material on the tread surface of a railroad wheel. In extreme cases, the resulting impact loads and reduction in relative flange height can result in broken rails and train accidents. Figure 1 shows an example of a wheel with an extreme case of TBU.

Figure 1. Wheel with TBU Extending 3 in. Radially from the Tread Surface

The Federal Railroad Administration (FRA) Office of Research, Development, and Technology and the Association of American Railroads (AAR) fund research conducted by Transportation Technology Center, Inc. (TTCI) on the root cause of wheel-related accidents. The purpose of this project was to improve wheel performance by gaining a solid understanding of the root causes of TBU.

Existing studies of TBU are few. The literature points to excessive brake force as the source of TBU, but some uncertainty surrounds the exact mechanism. Transfer of metallic material from brake shoes to wheels cannot be ruled out as a source for some minor cases of TBU. However, migration of molten wheel steel during a wheel-slide event is a more plausible means to generate sufficient TBU material to become a safety concern.

To increase the knowledge base regarding TBU, TTCI inspected 21 service-worn wheelsets with varying amounts of built-up material on the treads. Dimensions of the TBU were measured, as well as the wheel profile, tread roughness, tread surface hardness, and magnetism of the wheels. TBU was present on both wheels of each wheelset. All but one wheelset showed obvious indications of sliding on the tread surface, although the visible slides were not always immediately adjacent to the largest mass of TBU material. A wheel-slide event was clearly the root cause of the TBU on the three wheelsets with TBU radial heights greater than 1 inch. The other data collected did not indicate anything remarkable about the TBU wheelsets that would have caused the TBU.

To further the understanding of the conditions necessary to create TBU, wheel-slide tests should be conducted including variations of railcar speed, gross axle load, moisture, and brake shoe type.

BACKGROUND

FRA and AAR both have rules designed to restrict wheels with TBU. A wheel with TBU at or greater than a 1/8-inch radial height is condemnable under AAR rules.

Literature sources concur that TBU is related to brake problems [1], but there is not a consensus on the mechanism that causes the material to build up on the wheel. Metal from brake shoes has long been suggested as a TBU source material [2], and in fact, the metal in brake shoes has been found in at least one case to be a source of small amounts of TBU [3]. Historically,

brake shoes were made of cast iron, but this is no longer the case because high-friction composition brake shoes began to replace cast iron shoes in the 1960s [4].

Significant sources of metal in modern brake shoes include “pickup” metal and tread conditioning brake shoes manufactured with either an iron insert or a high metal powder content. Figure 2 shows an example of a brake shoe with metal pickup composed of metallic wear particles embedded in the composition material.

Figure 2. Composition Brake Shoe with Embedded Pickup Metal

The presence of water has been shown to be a contributing factor to brake shoe metal pickup, if not TBU [5]. However, laboratory dynamometer tests designed to produce TBU on a full-scale railroad wheel using a variety of brake shoes under wet and dry conditions were unsuccessful. These tests were initiated after a small amount of TBU was inadvertently developed during a dynamometer test while using a brake shoe with high metal content. Extensive follow-up testing was conducted with a wide range of brake shoe forces and different brake shoes, including normal composition shoes, shoes with metal pickup, and brake shoes with high metal content. None of this testing produced any TBU on the wheel or pickup metal in the brake shoes [3].

A previous inspection of service-worn wheels with TBU found that the wheels had developed stronger magnetic fields and had rougher tread surfaces compared to other wheels removed from service. In that report, photographs of the only two wheels with heavy TBU showed large slide marks.

OBJECTIVES AND METHODS

The purpose of this project was to identify measures for improved wheel performance by gaining a solid understanding of the root causes of TBU on wheels. To this end, 21 service-worn wheelsets with TBU were inspected. Dimensions of TBU, wheel profile, tread roughness, tread surface hardness, and magnetism of the wheels were measured.

RESULTS

Each wheelset inspected had TBU present on both wheels. All but one wheelset showed obvious indications of sliding on the tread surface, although the visible slides were not always immediately adjacent to the largest mass of TBU material. Eleven of the wheelsets were marked as condemnable for slid flats, but only five were marked as condemnable for TBU. The remainder of the wheels had been sitting in the elements long enough to obscure the condemnable code markings. After cleaning off the rust and contaminants with a wire brush, wheel profiles, hardness readings, and surface roughness readings were made on a portion of the tread with no TBU. Table 1 lists statistical results of the inspection data.

Table 1. Statistical Results of the Inspection Data

Measurement	Min.	Max.	Avg.
TBU circumferential length (in.)	4.5	Entire circum-ference	45
TBU radial height (in.)	0.06	3	0.46
Wheel tread surface hardness (Brinnell)	349	499	425
Magnetism (Gauss)	0	4	0.9
Tread surface roughness (µ in.)	19	140	49

From a safety standpoint, the radial height of the TBU material was of primary concern. The three wheels with TBU in excess of 1-inch radial height all showed obvious signs of a wheel slide immediately adjacent to the TBU and a circumferential TBU length less than 20 inches. The root cause of the TBU on these three wheels was clearly a wheel slide event. Figure 3

shows the circumferential length and radial height of TBU on each wheel.

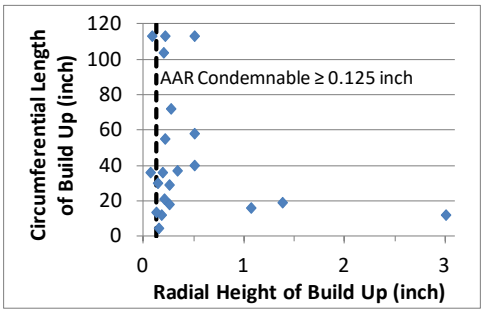

Figure 3. Dimensions of TBU

Tread surface hardness values and wheel profiles were typical of wheels removed from service. The magnetism and tread surface roughness were substantially less than in a previous report [3]. Measurement technique can explain some, but not all, of the magnetism discrepancy. Recent measurements were made solely on the tread and flange, whereas the previous measurements encompassed the entire wheel. Differences in surface preparation were the likely source of the discrepancies in the surface roughness readings.

CONCLUSIONS

TBU is associated with excessive brake force, most likely as a means of producing a wheel-slide event. Transfer of metallic material from brake shoes to wheels could be ruled out as a source for some minor cases of TBU. Wheels with TBU radial height greater than 1 inch showed clear signs of wheel slide as the root cause.

FUTURE ACTION

TTCI will conduct wheel-slide tests to investigate the conditions required to create TBU on wheels. Tests will include variations of railcar speed, gross axle load, moisture, and brake shoe type.

REFERENCES

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ACKNOWLEDGMENTS

TTCI wishes to thank the BNSF Railway for its assistance in the TBU wheelset inspection.

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KEYWORDS

Wheel, tread buildup, slide, brake

CONTRACT NUMBER

DTFR53-00-C-00012 TO253