Federal Railroad Administration, Office of Railroad Safety

Accident Investigation Summary Report HQ-2023-1847

Norfolk Southern Railway Company (NS) Derailment
New Castle, Pennsylvania
May 10, 2023

1. Executive Summary

On May 10, 2023, at approximately 10:57 p.m., EDT, Norfolk Southern Railway Company (NS) northbound freight train 14M (Train 1) derailed 9 cars at Milepost (MP) YG 75.56 on Main 1 track on the NS Youngstown Line subdivision, Keystone division, in New Castle, Pennsylvania. The train was 12,724 feet long, weighed 19,993 tons, and was configured with 1 head-end locomotive, 2 mid-train distributed power locomotives, 144 loaded freight cars, and 69 empty freight cars.

Lines 167 through 175 of the train consist derailed, after the left No. 1 (L1) roller bearing on car CRDX 3017 experienced a catastrophic failure. The roller bearing temperature was recorded at 253 °F above ambient temperature at the last hot bearing detector (HBD) the train passed, at MP YG 91.9 (Vale).

The Federal Railroad Administration's (FRA) investigation and analysis found that the probable cause of this accident was the failure of the L1 roller bearing on CRDX 3017 nearby. FRA determined the incorrect reinstallation of the Vale HBD that was performed on May 8, 2023, combined with the NS's back-office software logic, contributed to the cause of the accident. FRA further determined that transmissions from another HBD, in conjunction with multiple operational challenges, may have contributed to the accident.

2. Circumstances Prior to the Accident and NS's Hot Bearing Detector System and Processes

Train 1 having departed Conway, Pennsylvania, on May 10, 2023, and was traveling North on NS's main track of the railroad's Youngstown Line Subdivision destined for Conneaut, Ohio. Train 1's consist included 12 placarded hazardous materials tank cars, and the Train 1 was traveling 28 mph when the derailment occurred (which was under the maximum authorized speed of 40 mph).

Hot Bearing Detectors, Generally
HBDs are one type of wayside detector that railroads use to detect defective roller bearings of wheelsets that are mounted to on-track equipment. HBDs measure the temperature of wheel

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bearings on both ends of each axle (i.e., on both sides of a rail car) using infrared thermal detection systems.[1]

Generally, HBDs are designed to provide an alert when certain anomalies are detected, including:

- The difference between the temperature of a roller bearing surface and the ambient temperature exceeds a predetermined threshold (a "warm alarm" or "hot alarm");

- The temperature difference between a roller bearing and the mate bearing on the same axle exceeds a predetermined threshold (a "differential alarm"); or

- When other methods of calculating excessive roller bearing temperatures indicate a problem (e.g., when the readings of several HBDs indicate a trend of temperature increases).

An overheated bearing, if not addressed, will result in the bearing failing (commonly referred to as the bearing being "burnt off"). Overheated bearings result when the interior components of the bearing begin to rub together. The rubbing results in friction, which causes heat, which in turn degrades the bearing's lubrication. At some point the friction-generated heat causes the bearing's moving components to seize, and the bearing can no longer roll freely. When this happens, the axle begins to overheat, and ultimately the portion of the axle within the bearing fails and the truck is no longer supported, leading to the equipment's derailment.

NS HBD System Configuration and Processes

At the time of the derailment, NS's system of HBDs was configured to provide two types of alerts: (1) absolute alerts, and (2) non-critical alerts. NS's system was designed to trigger an "absolute alert" if a roller bearing temperature was measured as being more than 200 °F over ambient temperature (a "hot alarm"), and to trigger a "non-critical alert" if a roller bearing's temperature was measured as:

(1) being more than 170 °F over ambient temperature (but not more than 200 °F over ambient temperature) (a "warm alarm");

(2) having a temperature of 115 °F more than its mate bearing on the same axle (a "differential alarm"); or

(3) as "trending" warm (e.g., when the readings of several HBDs indicate a trend of a certain level of temperature increases or a spike in a bearing's detected temperature between HBDs).

[1]Another type of wayside detector used to detect defective roller bearings is acoustic bearing detectors (ABDs). ABDs are designed to automatically detect flaws in roller bearings by evaluating the acoustic signature of the noise created by a bearing flaw. ABDs are a newer technology and are only in limited locations across the U.S. FRA does not regulate wayside detectors, whether HBDs or ABDs.

NS's HBD system was further designed to communicate absolute alerts and non-critical alerts differently. Absolute alerts were directly communicated to both NS's Advanced Train Control (ATC) desk and to the crew operating the train in which the equipment triggering the alert was located. Specifically, for absolute alerts, an electronic message would be sent to the ATC desk, and an audible "talker" alert would also be immediately transmitted via radio to the train crew. Non-critical alerts, however, were only communicated to NS's ATC desk via an electronic message. A train crew would be made aware of a non-critical alert only if the ATC desk analyst or some other party (e.g., a dispatcher once notified of the alert by the ATC desk analyst) contacted them directly.

3. THE ACCIDENT

On May 10, 2023, at approximately 10:17 p.m., the train passed an HBD at MP YG 91.9 (Vale). The Vale HBD recorded the temperature of the L1 roller bearing on CRDX 3017 to be 253 °F over the ambient temperature.

Only one minute later (at 10:18 p.m.), the Vale HBD broadcast a message over the radio indicating that a critical alarm relating to the 671st axle in Train 1 was triggered. The message, however, was not heard by the crew. Axle 671 correlated with the L1 roller bearing on CRDX 3017.

Thirty-four minutes later (at 10:52 p.m.), the L1 roller bearing on CRDX 3017 experienced a catastrophic failure, resulting in an initial point of derailment (POD) at MP YG 75.56. The train proceeded north with the crew unaware of the derailed car.

Five minutes later (at 10:57 p.m.), an additional eight cars (lines 168 through 175) derailed at MP YG 74.9, resulting in an undesired emergency brake application.[2]

4. INVESTIGATION AND ANALYSIS

FRA conducted a comprehensive investigation and analysis of this accident. FRA's investigation included evaluation of each crew member's qualification, certification, and testing records, as well as the crew's actions. FRA evaluated and found no evidence of deficiencies, irregularities, or non-compliance with all aspects of the track over which the train was traveling at the time of derailment, as well as the various brake tests, equipment inspections, and repairs performed on the equipment in the train's consist prior to the accident.

FRA found no evidence of deficiencies, irregularities, or non-compliance in the crew's training, qualification, testing records, and the crew's hours of service records, or the crew's actions. FRA also conducted a fatigue analysis of each crew member's relevant work/rest schedule and found no excessive fatigue risk. In addition, the results of each crew member's FRA Post-Accident Toxicological Testing were negative, indicating that neither drugs nor alcohol contributed to the cause of the accident.

[2] An "undesired emergency brake application" means an unintentional and irretrievable application of the maximum braking force available from a train's brake system. An undesired emergency brake application is not intentionally initiated by the crew and occurs when there is a separation in a train's airline and air pressure is released from the system (e.g., when a derailment occurs).

FRA's investigation determined the probable cause of the accident was the failure of the L1 roller bearing on CRDX 3017, due to excessive friction between the bearing internal components. FRA additionally found a loose antenna, combined with the incorrect reinstallation of the Vale HBD that was performed on May 8, 2023, and the NS's back-office software logic, contributed to the cause of the accident.

Failure of the L1 Roller Bearing on CRDX 3017:
The L1 roller bearing on CRDX 3017 failed internally due to excessive friction between the bearing internal components. Because the L1 bearing cap had damage that obscured most of the part markings, the year of manufacture could not be determined. Markings on the locking plates indicated the bearing was reconditioned by Stucki, in Elizabethtown, Kentucky in 2008.

The reconditioned L1 bearing that failed displayed extensive thermal damage, and there was no trace of the polymer seals. The steel components within the bearing had portions galled and melted together, with extensive damage from rubbing and deformation. Some rollers within the bearing were flattened and fused to the mating components, and the bearing cap showed spalling damage that had occurred before the accident. There was a presence of silicon and evidence of wear that indicated there may have been dirt in the lubricant within the bearing.

When wheel bearings fail, they can do so without any apparent external appearance of a problem. A roller bearing can quickly become overheated and may even burn off in minutes. No evident defects were identified by the carman who inspected CRDX 3017 in Conway.

Problems with NS 4342 Radio Antenna System:
The crew did not hear a real-time alarm or train departure message[3] that the Vale HBD broadcast over the radio to their lead locomotive – NS 4342.

On May 13, 2023, a field test and inspection of the locomotive radio onboard was performed on the NS 4342. During the field test, it was discovered that the radio antenna connection was loose where it connected to the Radio Filter out connector on board the locomotive. It was observed that when the antenna connector was moved, the measured Voltage Standing Wave Ratio (VWSR) of the radio and antenna system resulted in a value outside the limits permitted by NS radio performance standards.

Additionally, on May 18, 2023, at the NS radio shop in Roanoke, Virginia, the locomotive radio underwent bench testing in a lab environment. The radio was a two-piece setup consisting of a radio deck mounted in the vestibule of the NS 4342 and a "faceplate" mounted on the locomotive's control stand. The radio deck and radio faceplate were determined to operate within manufacturer and Federal Communications Commission specifications; no faults were noted for either unit.

FRA determined that the loose connection of the NS 4342 radio antenna system may have contributed to the cause of the accident.

[3] A "train departure message" is the automated radio broadcast after a train has completely passed an HBD and usually includes summary information such as the HBD location, total potential problems detected, and whether "NO DEFECTS" were detected.

Incorrect Reinstallation of the Vale HBD and NS Back-Office Software Logic:
On May 8, 2023, NS signal maintainers removed the Vale HBD to facilitate track work in the area. After completion of the track work, the Vale HBD was reinstalled with the wheel transducers transposed. This incorrect installation reversed the perceived direction of the trains as they passed over the Vale HBD.

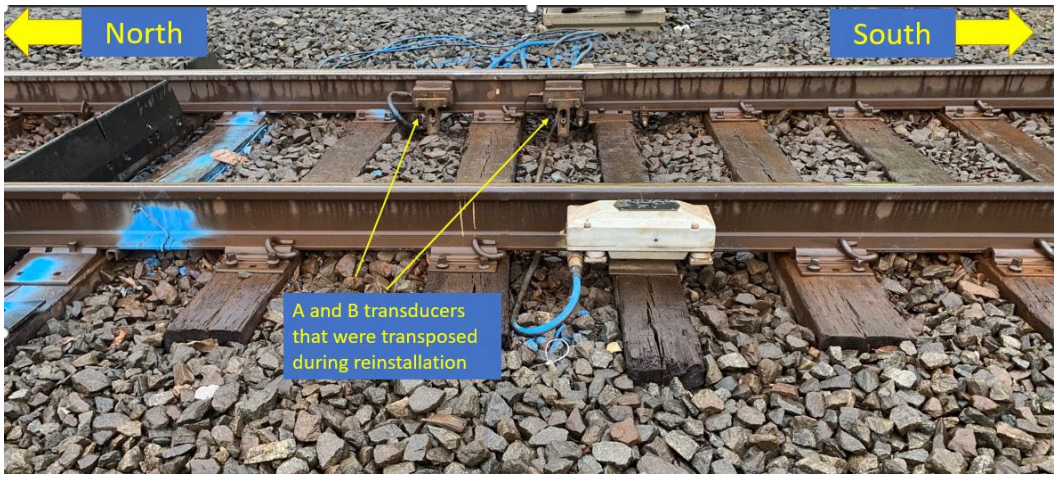

Figure 1: Vale HBD

Further, the software logic associated with transmitting alerts to the ATC desk was configured to match HBD data with other data stored on NS back-office computers, including expected train direction. On May 10, 2023, when Train 1 traversed the Vale HBD traveling north. the system recognized the hot axle and transmitted the radio message as intended; however, it thought the train was traveling south. Because the recorded travel direction perceived by the Vale HBD did not match the train's expected travel direction, the NS back-office software logic associated with transmitting HBD alerts dismissed the critical warning as "junk," and the alert was not forwarded to the ATC desk analyst.

FRA determined that the incorrect reinstallation of the Vale HBD, in conjunction with the design of the NS back-office software logic, prevented the ATC desk analyst from receiving the alert and possibly contributed to the cause of the accident.

Crew Confusion:
As Train 1 was traversing the Vale HBD, the crew was also dealing with multiple operational challenges. These challenges included: activating their Trip Optimizer system, attempting to restore communication with the End-of-Train Device, and communicating with the dispatcher over the radio.

Multiple radio transmissions were also being generated on the same radio channels by both the Vale HBD and the nearby Beaver Falls HBD, which was located at MP PC 30.5 on the Fort Wayne subdivision. Train 1 was not operating on the Fort Wayne Subdivision, and therefore never passed the Beaver Falls HBD. However, the Beaver Falls HBD is geographically only about one half-mile away from the Vale HBD, close enough for Train 1 to have received its radio transmissions. When Train 1 was passing the Vale HBD, another train was passing the Beaver Falls HBD. As a result, the two HBDs were generating and rebroadcasting their radio

transmissions in close temporal proximity. For example, the Beaver Falls HBD rebroadcast its "No Defects" message twice within approximately a minute of the Vale HBD generating its critical alarm radio transmission.

Based on its review of the track image recorder (TIR), inward-facing camera (IFC) footage, and audio recordings from the NS 4342 locomotive, FRA was able to confirm the Vale HBD transmission was not audible in the cab of the locomotive. The crew did hear the "No Defects" transmission from the Beaver Falls HBD, however, and mistakenly thought it was from the Vale HBD. The crew proceeded north under the impression there were no problems with their equipment.

FRA determined the multiple concurrent broadcasts from the Beaver Falls HBD, in addition to the multiple operational challenges may have contributed to the accident.

5. CONCLUSION

FRA's investigation and analysis of this accident determined that the probable cause of the accident was the failure of the L1 roller bearing on CRDX 3017 due to overheating. Contributing causes of the accident included incorrect installation of the Vale HBD, flaws in the NS back-office software logic, and the problems with the locomotive radio antenna. FRA further determined that the Beaver Falls HBD transmissions, in conjunction with multiple operational challenges, may have contributed to the accident.