

National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials

Washington, DC 20594



RRD23LR006

SAFETY PERFORMANCE OF WHEELSETS

Specialist's Factual Report
September 21, 2023

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A. ACCIDENT

Location: Springfield, OH
Date: March 4, 2023
Time: 4:54 p.m. Local Time (EST)
9:54 p.m. UTC
Train: Norfolk Southern Railway (NS) mixed freight train 179LC94

B. SAFETY PERFORMANCE OF WHEELSETS GROUP

Group Chair / IIC	Jim Southworth National Transportation Safety Board Washington, DC
Group Member	Joe Gordon National Transportation Safety Board Buchanan, Virginia
Group Member	David Casaceli National Transportation Safety Board Imlay City, Michigan
Group Member	David Graubard Federal Railroad Administration Harrisburg, Pennsylvania
Group Member	Jamie Harbour Public Utilities Commission of Ohio Columbus, OH
Group Member	Daniel Carter MxV Rail Pueblo, Colorado
Group Member	Elizabeth Allran Norfolk Southern Railway Roanoke, Virginia
Group Member	Glenn Brandimarte ORX Tipton, Pennsylvania

C. ACCIDENT SUMMARY

For a summary of the accident, refer to the *Preliminary Report* within this docket.

D. FACTUAL INFORMATION

On March 4, 2023, at about 4:54 p.m. local time, westbound Norfolk Southern Railway (NS) mixed freight train 179LC04 derailed 28 railcars at milepost 178.85 on the Dayton District near Springfield, Ohio.

Twenty-one of the derailed railcars were loaded and seven were empty; none were carrying hazardous materials. The train comprised three head-end locomotives, two mid-train distributed power units, and 212 railcars. The train was 13,470 feet long and weighed about 17,966 tons.

During the derailment, three wheelsets exhibited movement on their axles. One axle had one wheel completely dislodged from its axle seat, one axle had a wheel dislodged outboard, and a third axle had a wheel dislodge inboard.

The National Transportation Safety Board (NTSB) initiated an investigation focusing on the safety performance of wheelsets. FRA led the investigation of this accident.

1.0 Initial Investigation and Industry Response

The NTSB initially requested that NS recover eight wheelsets from two of the derailed railcars; photographs taken on scene after the derailment show that three wheels from these wheelsets exhibited movement on their axles. The NTSB subsequently placed an investigative hold on these wheelsets. NS also held additional wheelsets, other truck components from the accident train, and wheelsets from elsewhere in the NS fleet for examination.

After this derailment, on March 7, 2023, NS began removing 517 railcars built by National Steel Car from service.

Additionally, AAR issued an equipment inspection order (EI-0033) on March 9, 2023, advising railroads to inspect and remove from service wheelsets that were mounted by National Steel Car between August 2022 and March 2023.

The wheelsets held by the NTSB and other components were delivered to an NS facility in Altoona, Pennsylvania, for an examination performed before all parties. This examination began on March 15, 2023.

1.1 Wheelsets Held for Investigation

NTSB placed an investigative hold on twelve wheelsets from three cars of the derailed train. The wheels on three of the wheelsets had moved from their seats on their axles during the derailment. Each wheelset held by NTSB was mounted by National Steel Car around the same time as those exhibiting movement on their axles in the derailment.



Figure 1. Wheelsets from car NS 162581 held by NTSB for investigation at the derailment scene.

Additional wheelsets that were mounted by National Steel Car around the same time as those held from the derailed train were also sent to the same NS facility in Altoona, PA, for examination.

The wheelsets held for potential further examination are outlined in Table 1.

Table 2. Table of National Steel Car wheelsets held for investigation.

Car Number - Axle Position	Source	Notes
NS 162581 #1	Springfield, OH derailment; derailed car, 71st of consist;	Wheel 05987 not dislodged; Wheel 05523 dislodged outboard;
NS 162581 #2	Springfield, OH derailment; derailed car, 71st of consist;	Wheel 05508 not dislodged; Wheel 05544 dislodged inboard entirely off its seat.
NS 162581 #3	Springfield, OH derailment; derailed car, 71st of consist;	n/a
NS 162581 #4	Springfield, OH derailment; derailed car, 71st of consist;	n/a
NS 162582 #1	Springfield, OH derailment; derailed car, 72nd of consist;	Wheel 07084 not dislodged; Wheel 07340 dislodged inboard
NS 162582 #2	Springfield, OH derailment; derailed car, 72nd of consist;	n/a
NS 162582 #3	Springfield, OH derailment; derailed car, 72nd of consist;	n/a
NS 162582 #4	Springfield, OH derailment; derailed car, 72nd of consist;	n/a
NS 162548 #1	Springfield, OH derailment; derailed car, 70th of consist;	n/a
NS 162548 #2	Springfield, OH derailment; derailed car, 70th of consist;	n/a
NS 162548 #3	Springfield, OH derailment; derailed car, 70th of consist;	n/a
NS 162548 #4	Springfield, OH derailment; derailed car, 70th of consist;	n/a
NS 162438 #1	Elkhart, IN	n/a
NS 162438 #2	Elkhart, IN	n/a
NS 162438 #3	Elkhart, IN	n/a
NS 162438 #4	Elkhart, IN	n/a
NKLX 400172 #1	Elkhart, IN	n/a
NKLX 400172 #2	Elkhart, IN	n/a
NKLX 400172 #3	Elkhart, IN	n/a
NKLX 400172 #4	Elkhart, IN	n/a
NKLX 400264 #1	Burns Harbor, IN	n/a
NKLX 400264 #2	Burns Harbor, IN	n/a
NKLX 400264 #3	Burns Harbor, IN	n/a
NKLX 400264 #4	Burns Harbor, IN	n/a

2.0 AAR Wheel Mounting Standards

AAR develops and publishes rules governing wheel shop practices, including axle and wheel bore machining and mounting practices. These rules are included in AAR's Safety and Operations Manual of Standards and Recommended Practices Section G-II Wheel and Axle Manual, Effective October 2022 (MSRP G-II). NTSB investigators reviewed these standards to determine those sections applicable to the movement of wheels on their axles.

Section 1.0 of this manual outlines the Mandatory Rules Governing Wheel Shop Practices as Required by Interchange Rules. Table 2 below summarizes some of the applicable standards to this investigation.

Table 3. Summary table of AAR MSRP G-II rules applicable to axle and wheel bore mounting and machining.

Rule Number	Selection of Applicable Standards
1.1	Requirements for the dimensions and specifications of newly finished axles including wheel seat rotundity, and taper. Wheel seat rotundity must not exceed 0.002 inches. Inboard wheel seat diameter must be greater than or equal to the wheel seat diameter at the centerline of the wheel seat; diameter at the centerline of the wheel seat must be greater than or equal to the outboard wheel seat diameter.
1.3.3	Bore rotundity must not exceed 0.002 inches. If a bore taper exists, the taper must have the smaller diameter on the outside of the hub bore.
1.3.4	Wheel bore must be sufficiently smaller than wheel seat diameter to enable required mounting force to be obtained. Generally, an interference fit of .001 inch per inch of wheel seat diameter will result in desired mounting forces.
1.3.5	Two or more separate cuts must be made in boring new steel wheels. Finish cuts must have a minimum of 30 uniformly spaced grooves per bore and the maximum groove depth may not exceed 0.008 inches.
1.4.1	Requirements for recording wheel mounting force records for each wheel and the requirements for maximum mounting force and additional limits on the shape and nature of the mounting forces, including upper and lower limits, maximum drop-off and different locations in the mounting force curve, tonnage build profile, entry force spikes, and pounding or slip-stick behavior.
1.4.3	Requirements for preparing wheel seats and bores for mounting including cleaning and the use of an AAR approved mounting lubricant.
1.5.3	Requirements for freight car wheel back-to-back measurements.

3.0 Wheel and Axle Manufacturing and Mounting Records

NTSB reviewed National Steel Car records created during the manufacturing process for the wheelsets and axles that had wheels dislodged during the derailment. All these records reflected adherence to proper manufacturing standards, including for wheel mounting forces upper and lower limits and the additional requirements of Rule 1.4.1 of the AAR MSRP G-II.

4.0 Wheelset and Axle Seat Investigation

On March 15 to 17, 2023, at the NS Juniata Shop in Altoona, PA, and the ORX facility in Tipton, PA, NTSB and other party members conducted a further inspection of the wheelsets held for investigation. This inspection included dismounting five wheels and performing detailed visual inspections and measurements of the wheel bores and axle seats. Additionally, on March 21 and 22, 2023, a portable coordinate measurement machine was used to gather additional data from the dismounted wheels at the NS Juniata Shop in Altoona, PA, and wheel 05544, which completely dislodged in the derailment.

4.1 Physical Inspection - NS Juniata Shop - Altoona, PA

The five wheelsets from the derailed cars NS 162581 and NS 162582 that did not visually appear to dislodge their wheels during the derailment were measured for wheel back-to-back spacing in three locations approximately evenly spaced around the wheels. Each of these wheelsets' back-to-back measurements was within the AAR MSRP G-II specifications for back-to-back measurements. They did not exhibit evidence of the wheels moving on their axles nor of conditions that would lead to such movement. Additional wheelsets were examined that were manufactured by National Steel Car around the same time as those that exhibited movement of wheels on their axles in the derailment. These wheelsets were obtained from two cars in Elkhart, IN (4 wheelsets each from car NS 162438 and car NKLX 400 172). These wheelsets were examined in the same manner. None of these wheelsets exhibited evidence of wheels moving on their axles or of conditions that would lead to such movement.

The axle containing wheel 05544 that was completely dislodged in the derailment was cut to remove the dislodged wheel. The mate wheel to wheel 05544 (wheel 05508) was pressed from the axle, and the wheel bore and axle seat of each wheel from that axle were visually examined for evidence of movement on the axle, along with conditions that could lead to such movement, such as fretting. No evidence of movement on the axle prior to the derailment was identified. The wheel bores for wheels with serial numbers 05523, 05987, 07084, 07340, and 05508 from cars NS 162581 and NS 162582 each contained between 31 and 32 machining grooves per bore.



Figure 2. Wheel bore of wheel 05508 from car NS 162581 after being pressed from its axle.

4.2 Wheel Dismounts and Measurements - ORX Facility - Tipton, PA

The remaining two wheelsets that had wheels dislodged from their seat during the derailment from cars NS 162581 and NS 162592 were sent to the ORX Railway Corporation facility in Tipton, PA. The two axles with a wheel partially dislodged from its seat had each wheel pressed from the axle, recording the required force to break the wheel free from its seat and the force required to slide the wheel off its seat. There are no AAR or other industry standards for wheel dismount forces. A summary of these measurements is in Table 3 below. No destructive testing was performed on any wheels or axles placed on NTSB hold.

Table 3. Summary of wheel dismount forces recorded at ORX Railway Corporation in Tipton, PA.

Car-Wheel	OEM Mounting Force (tons)	Break Force (tons)	Break Force % of OEM	Slide Force (tons)	Slide Force % of OEM	Note
162581-05523	116	166	144%	136	118%	Dislodged outboard
162581-05987	129	160	124%	148	115%	Normal looking position
162582-07084	135	174	129%	162	120%	Normal looking position
162582-07340	128	106	83%	80	62%	Dislodged inboard

After dismounting at ORX, the diameter, taper, and rotundity of all four wheel bores and their corresponding axle seats were measured. Axle seat surface roughness was also measured. No AAR or other industry standards exist for post-dismount axle or wheel dimensions. However, all measurements indicated the axles and wheel bores were manufactured and mounted within specifications, with one exception. The bore of wheel 07340 exhibited anomalies in its bore diameter regarding the bore taper and maximum deviation in bore measurements. As a result of this anomaly, additional investigative actions were performed utilizing 3D scans of wheelset axle seats and wheel bores.

4.3 3D Wheel Bore Scans - NS Juniata Shop - Altoona, PA

On March 21 and 22, 2023, at the NS Juniata shop in Altoona, PA, a portable coordinate measuring machine was used to gather precise three-dimensional data of wheel bore profiles. Six wheel bores from three axles were examined with the equipment: the three wheels that exhibited movement on their axles in the derailment and each of these wheels' axle mates, which exhibited no movement before being dismounted as part of the investigation.

Using the scan data, the wheel bore machining profile was compared to nominal parameters and to those of a new, unmounted wheel produced on March 28, 2023, at National Steel Car.

The results show that the machining profiles of each wheel was close to the nominal and new wheel bore machining profile, although it should be noted that there are no AAR requirements for wheel bore finish on dismounted wheels.

The machined bore profiles of each wheel were examined to determine the number of machine grooves per bore, the machining groove depth, and the radius within groove cross sections. Table 4 below provides the values produced from the scans, including the nominal machining parameters and those of a new, unmounted wheel. When comparing a new, unmounted wheel to a wheel that has been mounted and dismounted, it is expected to have changes such as a reduction in groove depth due to the mounting and dismounting processes. As stated, there are no AAR requirements for wheel bore finish on dismounted wheels.

Table 4. Summary data for wheel bore profiles from 3D scans. All values are in inches.

Wheel ID	Average Groove Depth	Distance over 5 consecutive peaks	Average peak to peak value	Average valley radius
Nominal	0.0055	1.050	0.210	1.00
18135 new wheel (unmounted)	0.0041	0.952	0.190	0.93
05508 dismounted	0.0023	1.029	0.206	1.18
05544 dismounted	0.0037	1.069	0.214	0.83
05523 dismounted	0.0029	1.051	0.210	0.93
05987 dismounted	0.0030	1.042	0.208	0.87
07340 dismounted	0.0029	1.044	0.209	0.87
07084 dismounted	0.0029	1.047	0.209	0.98

Wheel 05544, which moved off its seat in the derailment, showed asymmetric distortion of the wheel bore on the front side (outboard) and a smaller localized area of distortion on the inside (inboard), directly opposite. A similar pattern of distortion, though of a lesser magnitude than that present on wheel 05544, was present on the outboard front side of wheel 07340, which dislodged in the derailment.

Damage was noted on the rim of wheel 05544, opposite of the area of distortion in the wheel bore. Additionally, damage was present on the bearing end cap on the opposite end of the axle of dislodged wheel 05544.

Heavy damage was noted on the rim of 07340, opposite of the area of distortion in the wheel bore. Damage was also noted on the bearing end cap on the opposite end of the axle of dislodged wheel 07340.

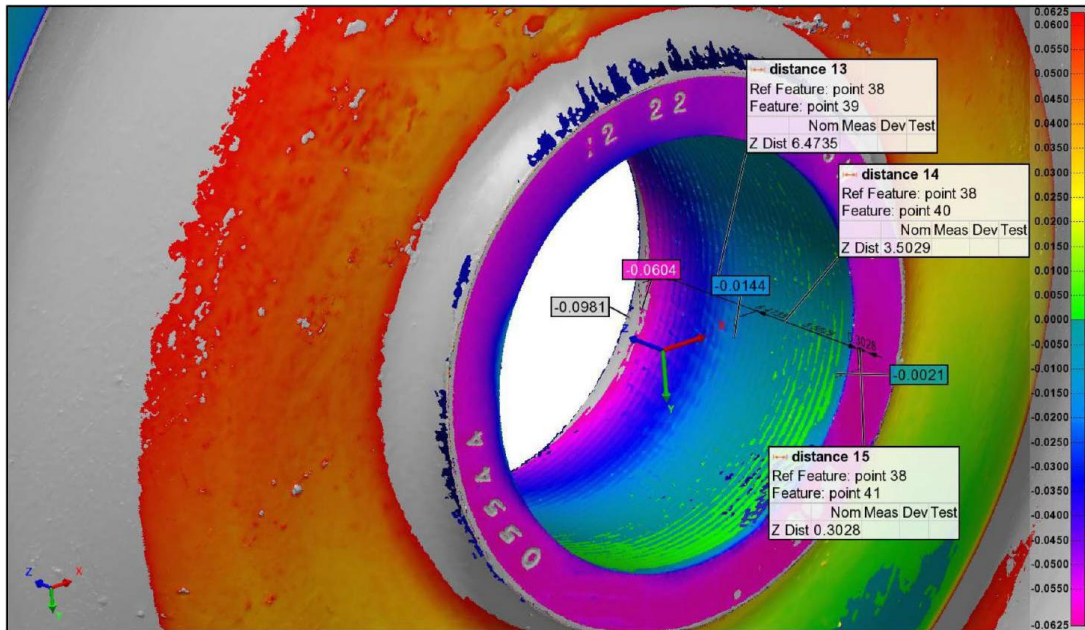


Figure 3. Image generated during 3D scan of wheel 05544 showing the overall variation in the shape of the wheel bore compared to a 3D model of a nominal wheel. A large amount of distortion on the outboard side is evident. View from inboard side of wheel.

5.0 AAR Cancels Equipment Instructions

On April 13, 2023, the AAR Wheels, Axles, Bearings and Lubrication committee voted to cancel EI-0033 that it issued on March 9, 2023, which had advised railroads to inspect and remove from service wheelsets that were mounted by National Steel Car between August 2022 and March 2023. Equipment Instruction EI-0033 Supplement 01 removed all cars from the advisory and informed car owners that they may request to have wheelsets quarantined by EI-0033 placed back under their own cars.

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