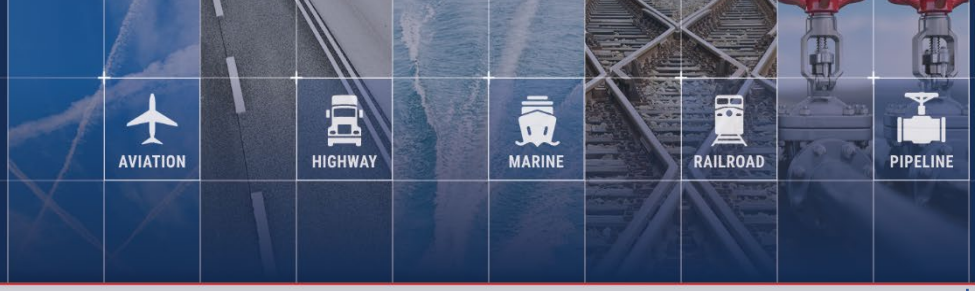

November 14, 2023 Railroad Investigation Report RIR-23-14

Norfolk Southern Railway Contract Roadway Worker Fatality

Reed, Pennsylvania
December 8, 2021

Abstract: On December 8, 2021, about 11:20 a.m. local time, a Norfolk Southern Railway rail gang was working on a main track in Reed, Pennsylvania. Three roadway maintenance machines (referred to as Spikers 1, 2, and 3) were driving spikes into the crossties. The operator of the second spiker, Spiker 2, noticed that he had closed the distance with Spiker 1 and decided to back up to assist Spiker 3. The Spiker 2 operator reported that he blew the horn, looked in his mirror, reversed direction, and struck a contract roadway worker, who was between Spikers 2 and 3. Spiker 2 came to a stop on top of the worker, who was fatally injured. Safety issues identified in this investigation are inaudible warning devices, inadequate inspections of roadway maintenance machine horns and change-of-direction alarms, and the inadequate protection provided by the requirement for 25-foot separation between workers and roadway maintenance machines. The National Transportation Safety Board issues new safety recommendations to the Federal Railroad Administration, to all Class I railroads, to Norfolk Southern Railway, and to the American Short Line and Regional Railroad Association.

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Acronyms and Abbreviations

ANSI	American National Standards Institute
ASLRRA	American Short Line and Regional Railroad Association
CFR	*Code of Federal Regulations*
FRA	Federal Railroad Administration
NFPA	National Fire Protection Association
NS	Norfolk Southern Railway
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
RMM	roadway maintenance machine

Executive Summary

What Happened

On December 8, 2021, about 11:20 a.m. local time, a National Salvage and Service Corporation worker who was part of a Norfolk Southern Railway (NS) work gang was struck and killed by a roadway maintenance machine (RMM) on a main track in Reed, Pennsylvania. Three RMMs, or spikers, were driving railroad spikes into crossties when the middle spiker (Spiker 2) reversed direction. The operator reported that he blew the spiker's horn and looked in the mirror before reversing but did not see the National Salvage contract worker standing behind the spiker.

What We Found

Spiker 2 was equipped with a horn and a change-of-direction alarm to alert anyone nearby to a change in direction. However, only one of the four trumpets on the horn was working, and the speaker for the rear change-of-direction alarm was unplugged, so the alerts provided by the horn and the alarm were barely louder than ambient noise and likely would not have been detectable to someone standing at least 25 feet from the rear of the spiker. It is likely that the rear change-of-direction alarm speaker was unplugged because the spiker was shipped from the manufacturer, Nordco Inc., with incorrect connections, causing the change-of-direction alarm to provide alerts improperly; in this case, the rear alarm on Spiker 2 would provide an alert from the rear speaker when the spiker was moving forward. We found that the preshift inspection was not comprehensive enough to detect the inaudible alerts from the change-of-direction alarm and the horn.

We found that NS's 25-foot standoff distance rule is inadequate to ensure that operators can see roadway workers who are standing more than 25 feet behind an RMM, because it does not consider the unique design and visibility limitations of each RMM. In addition, a functioning backup camera on the RMM would have allowed the operator to detect the contract worker before reversing the machine.

We determined that the probable cause of the Reed, Pennsylvania, accident was the inability of the spiker operator to see the contract worker behind the spiker and the contract worker not being alerted by the spiker's nonfunctional horn and change-of-direction alarms. Contributing to the accident was (1) Norfolk Southern Railway's preshift inspection that did not check the audibility of the spiker's alerts above ambient noise; (2) Nordco Inc. allowing the spikers to leave the factory without assuring the change-of-direction alarm was working; and (3) insufficient standoff

distance chosen by Norfolk Southern Railway that did not provide adequate visibility behind the spiker.

What We Recommended

We recommended that the Federal Railroad Administration require all new and all rebuilt and remanufactured RMMs to be equipped with backup cameras. We also recommended that all Class I railroads equip new and existing RMMs with backup cameras and that the American Short Line and Regional Railroad Association advise its members of this accident and of the importance of adding backup cameras to new and existing RMMs. Furthermore, we recommended that the Federal Railroad Administration inform railroads of the need to determine the appropriate standoff distance for all RMMs.

We recommended that NS revise their RMM preshift inspection procedures to make sure the change-of-direction alarm and the horn sound in the correct direction and can be heard at least 25 feet from the machine. We also recommended that NS revise its RMM standoff distance rule to ensure clear visibility of roadway workers in front of and behind the machines.

1 Factual Information

1.1 The Accident

On December 8, 2021, about 11:20 a.m. local time, a National Salvage and Service Corporation contract roadway worker assigned to work with a Norfolk Southern Railway (NS) rail maintenance crew (gang) was struck and killed when the operator of a spike machine reversed direction in Reed, Pennsylvania.[1] The NS rail gang, called R-12, was working on the NS Buffalo Line main track 1 at milepost 295.1. Three roadway maintenance machines (RMMs), referred to as Spikers 1, 2, and 3, were driving spikes into the crossties, working from north to south. The operator of the second RMM, Spiker 2, noticed that he had closed the gap with Spiker 1 and decided to back up to assist Spiker 3, which was working more slowly behind him.[2] The Spiker 2 operator said he blew the horn, looked in his mirror, reversed direction, and struck the National Salvage contract worker, who was standing in the track gauge between Spikers 2 and 3. At the time of the accident, the weather was cloudy with cold temperatures, but no precipitation or obscuration was reported.

On the day of the accident, NS's R-12 rail gang was removing and installing 1,342 feet of continuous welded rail between mileposts BR 295.00 and BR 295.25. The R-12 rail gang was composed of 28 workers working with 15 RMMs. Three of the RMMs manufactured by Nordco Inc. were spikers, used to install spikes after the rail had been laid.[3] Two workers and a grapple truck were contracted from National Salvage.[4] One contract worker was tasked with marking old rail for scrap and resale purposes, and the other worker operated the grapple truck to pick up the scrap rail.

About 7:30 a.m., the R-12 rail gang, including the two contract workers from National Salvage, attended a job safety briefing, which covered safety hazards and

[1] Visit www.ntsb.gov to find additional information in the public docket for this National Transportation Safety Board (NTSB) accident investigation (case RRD22LR003). Use the CAROL Query to search safety recommendations and investigations.

[2] According to crewmember interviews with the NTSB, it was standard operation for Spiker 2 to work forward and then reverse to help Spiker 3.

[3] The spikers' model name was the SE Hammer Production Spike Driver.

[4] (a) According to their website, "railroad track removal and demolition is National [Salvage]'s core business." (https://www.nssccorp.com/rail-services, accessed March 3, 2023.) (b) A *grapple truck* has a rotating boom mounted to the truck frame, with grapple and bucket attached, used for loading and hauling large waste.

the work plan for the day. After the briefing was complete, the RMM operators started their equipment and performed a walk-around preshift inspection of the equipment. In a postaccident interview with the National Transportation Safety Board (NTSB), the Spiker 2 operator stated that he discovered no issues in his inspection of the RMM.[5]

The equipment was then moved to the job site. Once the work equipment was in place, the work crews were instructed to begin removing the old rail and installing the replacement rail. Spiker 2 was working in a southward direction between the two other spikers, Spiker 1 to its south and Spiker 3 to its north.[6]

In a postaccident interview with the NTSB, the Spiker 1 operator reported that, about 5 to 7 minutes before the accident, he saw the contract worker cross in front of Spiker 1, walk northward along the west side of the track, cross the track again behind Spiker 1, and continue walking northward along the east side of the track. The Spiker 3 operator stated in interviews with the NTSB that he saw Spiker 2 strike the contract worker. He further stated that the worker was facing the side of the track and was not looking toward Spiker 2 and that he had not seen the contract worker standing between the two spikers that day.

The operator of Spiker 2 stated that he looked in his left side-view mirror (the right side-view mirror was not visible from where he was seated), viewing the east side of the track, and did not see anyone standing behind the spiker. He then blew the spiker's horn three times and started to reverse Spiker 2 toward Spiker 3. Spiker 2 then struck the contract worker. He recalled that, upon reversing, he felt like he had backed over a rail weld. When he looked down at the track, he noticed the contract worker underneath the spiker. The operator immediately made an emergency radio call stating that a worker was under his machine and that emergency services were needed; he then shut down the spiker. Members of the rail gang attempted to lift the spiker from on top of the contract worker.

Figure 1 shows the accident location before impact, with the contract worker located 29 feet 11 inches north of the rear of Spiker 2 on the main track 1, and the final resting location of the contract worker beneath Spiker 2, 35 feet and 10 inches north of his original location as measured during postaccident site examinations.

[5] In the interview, the operator of Spiker 2 stated that if he had discovered any problems with the RMM, he would immediately have reported the problem to the mechanics for repairs.

[6] In an interview with the NTSB, the operator of Spiker 3 estimated that Spiker 2 was about 125 feet ahead of Spiker 3 before reversing the machine.

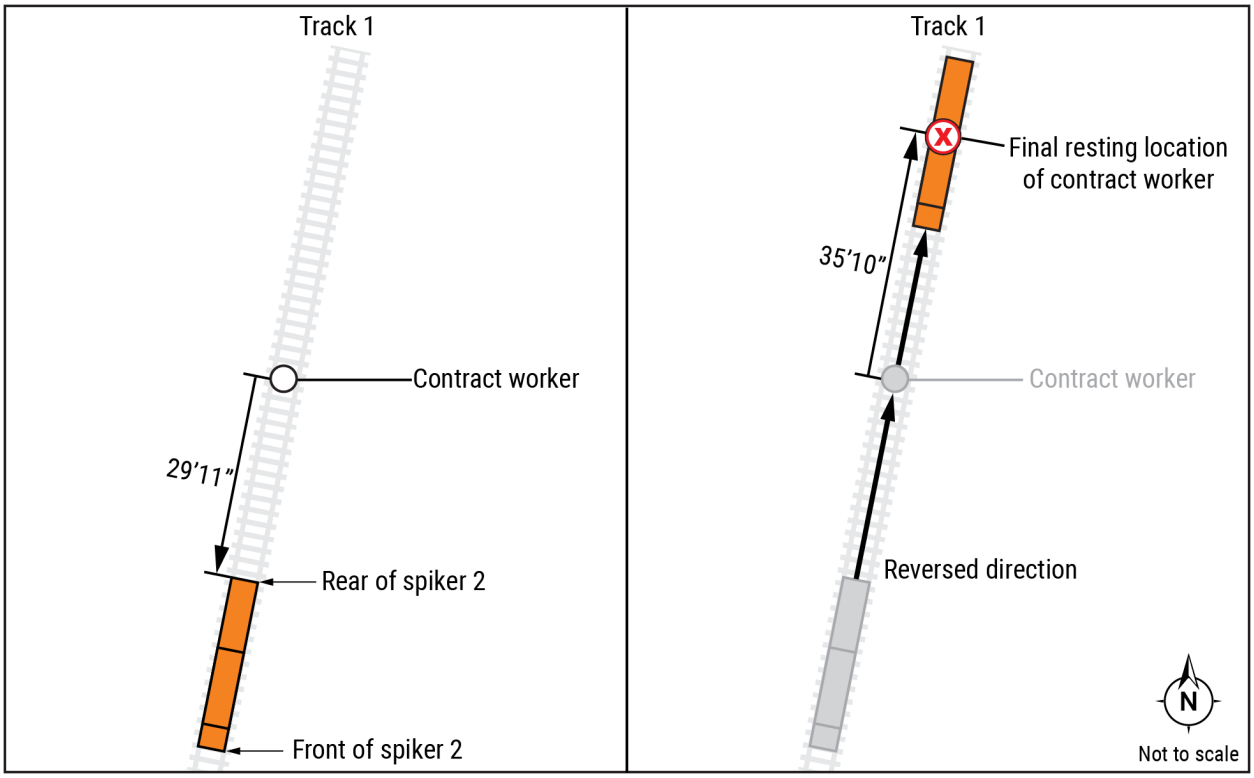

Figure 1. Positions of Spiker 2 and contract worker before and after the accident.

1.2 Emergency Response

The first 9-1-1 call was received at the Dauphin County Emergency Communications Center in Harrisburg, Pennsylvania, at 11:20:38 a.m. The NS worker who placed the call could not pinpoint the location of the accident. A second call was placed by another NS worker at 11:24:21 a.m. and emergency services were dispatched at 11:25:24 a.m.

Dispatch records show that first responders arrived about 11:35 a.m. and reported that the contract worker was being extricated from under Spiker 2 by members of the rail gang. The contract worker was unresponsive when the first responder arrived; he was pronounced dead by the emergency medical services supervisor about 11:49 a.m.

1.3 Equipment

Spiker 2 was built in December 2015. (See figure 2.) These spikers were rail-bound machines that used opposing, hydraulically driven, high-impact spiking hammers to drive spikes into place on a railroad track. The spikes were fed from a bin at the rear of the cab into a loading mechanism. The enclosed, climate-controlled cab

had seating on either side for a machine operator and in the middle for one feed-tray worker. Operators moved the machine using foot pedals and controlled the insertion of spikes along the two tracks using an electronic joystick; each side had two direction-of-travel foot pedals (one forward and one reverse) and one joystick. On the day of the accident, only the left-side track was being spiked, so one operator was in the left-hand seat and a worker was loading spikes from the middle seat. The maximum working speed of the spiker was 8 mph.

Figure 2. Spiker 2 at the accident scene. The front of the spiker is to the right.

1.3.1 Spiker Warning and Rearward Viewing Devices

As required by Federal Railroad Administration (FRA) regulations, the spikers involved in the accident were equipped with warning devices to alert personnel working near the machines of a change in direction.[7] The warning devices included an automatic change-of-direction alarm with exterior front- and rear-mounted speakers, lights, and a horn system.

[7] Title 49 *Code of Federal Regulations* (*CFR*) 214.511, Required audible warning devices for new on-track roadway maintenance machines.

The spikers were also equipped with rear view mirrors as required by FRA regulations, one on each side of the machine.[8] Warning signs affixed to the rear of the spikers alerted personnel to the standoff distance of 25 feet (NS 2019). (See figure 3.) According to the NS rail gang supervisor, some RMMs in the NS fleet are equipped with backup video cameras. The spikers working on the day of the accident were not.

Figure 3. Standoff warning sign on the rear of Spiker 2.

1.3.1.1 Change-of-Direction Alarm and Lights

The change-of-direction alarm was designed to activate both based on the position of a forward/reverse travel toggle switch, indicating the working direction of the spiker, and the direction-of-travel foot pedal used by the operator.[9] For example, if the toggle switch was in the forward position and the operator used the reverse direction-of-travel pedal, the change-of-direction alarm would sound through the rear

[8] Title 49 *CFR* 214.509, Required visual illumination and reflective devices for new on-track roadway maintenance machines.

[9] The *forward/reverse travel toggle switch* was a three-position switch (forward/center/reverse) located on the spiker's main control cabinet.

speakers. If the toggle switch was in the reverse position and the operator used the forward direction-of-travel pedal, the change-of-direction alarm would sound through the front speakers.

The spiker's lights would illuminate based on the position of the toggle switch; the work lights on the front of the spiker (and red marker lights on the rear of the spiker) would illuminate when the toggle switch was in the forward position and vice versa. If the toggle switch was in the center position, both the forward and rear change-of-direction alarms and lights would sound and illuminate, respectively, no matter which pedal was used.

1.3.1.2 Horn System

According to FRA regulations, all RMMs must have a horn or other audible warning device that produces "a sound loud enough to be heard by roadway workers and other machine operators within the immediate area."[10] Each of the spikers involved in the accident were outfitted with two forward-facing and two rear-facing trumpets that sounded when the operator pressed the button to activate the horn.

1.3.2 NS Equipment Inspection Requirements

FRA regulations require that the operator of an on-track roadway maintenance machine check the machine components for compliance with Title 49 *Code of Federal Regulations* (*CFR*) Part 214 Subpart D before using the machine at the start of the operator's work shift.[11] The regulation states that any noncomplying condition that cannot be repaired immediately must be reported and affixed with a tag that indicates the exception, or noncomplying condition, along with the date, location, and name of the individual that reported the exception.[12] If the horn is not operational, then a portable horn may be substituted for up to 7 calendar days.[13]

[10] Title 49 *CFR* 214.511 (a) and 49 *CFR* 214.513, Retrofitting of existing on-track roadway maintenance machines; general.

[11] Title 49 *CFR* 214.527 (a), On-track roadway maintenance machines; inspection for compliance and schedule for repairs.

[12] (a) Title 49 *CFR* 214.527 (b). (b) The FRA Machine Safety Exception Tag includes checkboxes for equipment exceptions that must be noted. Exceptions include defective change-of-direction alarms and back-up alarms and horns.

[13] Title 49 *CFR* 214.527 (c) (2).

Change-of-direction alarms that are not operational must be repaired or replaced as soon as practicable within 7 calendar days.[14]

NS operating rules state: "Before On-Track equipment is placed in service, daily inspection must be made for loose bolts, missing cotter keys, fuel leaks, improper brake adjustment, improper wheel gauge, worn wheels, and other items as instructed" (NS 2019a).[15] In addition to the preshift inspection conducted by the equipment operators, NS's maintenance department performs a monthly inspection. During the inspection, mechanical defects are identified, documented, and repaired or replaced.

1.4 Personnel Information

1.4.1 Spiker 2 Operator

The Spiker 2 operator was hired by NS on October 2, 2012, and was qualified to operate the spikers on August 21, 2014. At the time of the accident, the operator had been assigned to Spiker 2 for about 3 months. NS records indicate that 16 rules checks were conducted in 2021 for the Spiker 2 operator, and no deficiencies were noted.[16]

The Spiker 2 operator provided the NTSB a 72-hour history of his work and rest schedule. He stated in an interview with the NTSB that he was staying at a hotel at the time of the accident and added that he typically would go to sleep around 8:00 or 9:00 p.m. and wake up around 3:00 a.m. The operator said that on the day of the accident, he went on duty about 6:30 a.m. and traveled about 30 to 40 minutes from the hotel to the job site.[17] He stated that the job safety briefing took place around 7:30 a.m. and that he did not feel fatigued on the day of the accident.

The NTSB reviewed the cell phone records of the Spiker 2 operator. He was not using his cell phone at the time of the accident.

[14] Title 49 *CFR* 214.527 (c) (4).

[15] NS generally follows FRA inspection requirements in 49 *CFR* 214.527.

[16] *Rules checks* are tests on rules compliance conducted periodically on railroad employees.

[17] NS workers are on duty from the time they leave the hotel to the time they return.

1.4.2 National Salvage Contract Worker

The contract worker was hired by National Salvage on August 5, 2019. He completed NS's roadway worker protection training and received the required contractor certification for working on and around NS properties.[18]

National Salvage conducted six safety inspections for the contract worker between January 22, 2020, and February 23, 2021. The inspections focused on job site safety and included areas such as personal protective equipment (PPE), radio procedures, spacing of equipment, and working and walking conditions. Safety inspection records indicated that the contract worker demonstrated knowledge of the inspection areas and that no corrective action was needed.

The NTSB obtained a 72-hour work and rest history for the contract worker. The worker was not on duty on December 5, 2021. He returned to work on December 6, started his shift around 5:35 a.m., and went off duty about 6:45 p.m. On December 7, the day before the accident, the worker started his shift around 5:35 a.m. and went off duty about 8:36 p.m. His work shift started about 5:30 a.m. on the day of the accident.

A review of the contract worker's cell phone records revealed that he was not using his cell phone at the time of the accident, nor was he in the habit of using the cell phone during the periods available for him to rest.

1.4.3 Toxicological Testing and Autopsy Result

Postaccident toxicological testing was conducted on the Spiker 2 operator for alcohol and other drugs as required by the FRA.[19] No tested-for substances were identified.

[18] The areas covered in the roadway worker protection training included general safety, terms and definitions, job briefings and communications, working limits, train approach warning and individual train detection, on-track equipment, on-track safety on adjacent tracks, and alternate methods of protection.

[19] In accordance with 49 *CFR* Part 219 Subpart C, the operator's urine specimen was tested for amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, methylenedioxymethamphetamine/methylenedioxyamphetamine, methadone, opiates/opioids, phencyclidine, tramadol, brompheniramine, chlorpheniramine, diphenhydramine, doxylamine, and pheniramine. His blood specimen was tested for ethyl alcohol.

Postmortem toxicology testing of the contract worker as required by the FRA revealed that no alcohol or other tested-for drugs were detected.[20]

An autopsy of the contract worker was conducted by the Dauphin County Coroner's Office in Harrisburg. According to the autopsy report, the worker's cause of death was multiple traumatic injuries. The autopsy did not reveal any conditions that predisposed the contract worker to greater risk of accident involvement.

1.5 Weather

The closest weather reporting station was located 31 miles south of the accident site, at the Harrisburg, Pennsylvania, International Airport. At 10:56 a.m. on the day of the accident, the weather station reported cloudy conditions, a temperature of 35°F, and wind from the south–southwest at 6 mph. No precipitation or obscurations were reported for the area.

1.6 Operations and System Safety

1.6.1 Roadway Worker Separation

NS operating rules state that employees must maintain at least 25 feet of separation from RMMs (NS 2019). When necessary, employees may work closer than 25 feet to RMMs, provided that the employee and operator hold a job safety briefing and that all involved have a clear understanding of the RMM movement to be made.

1.6.2 Personal Protective Equipment

NS Safety Rule 1044 requires that contractors must wear an NS-approved high-visibility safety vest when required to be on any railroad tracks or right-of-way (NS 2019b). The rules allow other high-visibility garments to be worn in lieu of company-issued vests if the garment is a fluorescent yellow-green color and meets American National Standards Institute (ANSI) Class 2 or Class 3 standards for garment

[20] Tested-for substances included amphetamines, barbiturates, benzodiazepines, cocaine and marijuana metabolites, methadone, methaqualone, MDA-analogues, opiates, 6-acetylmorphine, oxycodone, opiates, phencyclidine, and propoxyphene.

size, reflectivity material, and performance.[21] The safety garment must be worn as the top layer of clothing.

The contract worker's PPE at the time of the accident included a hard hat with a light, eye and ear protection, footwear, and outer garments. These garments included a black outer coat with reflective material on the torso and sleeves that was incorporated into a neon pattern on the lower half of the garment. Under the coat, the worker wore black overall pants with reflective material around the mid-calf and a fluorescent yellow long-sleeved shirt with reflective material on the torso and encircling the waist. At the time of the accident, the outer jacket was zipped up so that the yellow shirt was not visible. Neither the outer jacket nor the overall pants met NS's Rule or the ANSI Class 2 or 3 standard.

Interviews conducted with the NS R-12 rail gang supervisor and the roadway worker in charge revealed that, although both individuals stated they were familiar with NS Safety Rule 1044, neither noted that the contract worker's PPE did not comply.

1.7 Postaccident Testing and Observations

1.7.1 Sight Distance Observations

On February 10, 2022, the NTSB conducted sight distance observations using subjects who were the same height as the Spiker 2 operator and the deceased contract worker. One subject (Subject 1) was seated in the left operator seat of Spiker 2. Another subject (Subject 2) stood variously to the left, center, and right of the track, and Subject 1 used the left side-view mirror to observe Subject 2 in the different locations.

The white dots in figure 4 represent the points at which Subject 2, standing in three locations on the track, first became visible to Subject 1. This point was 72 feet from the rear of Spiker 2 on the left side of the track, 39 feet from Spiker 2 in the center of the track, and 0 feet from Spiker 2 on the right side of the track. The black dot represents the position of the contract worker just before the accident sequence.

[21] ANSI establishes standards for reflective clothing and sets voluntary guidelines for high-visibility clothing. ANSI Class 2 and 3 garments provide more body coverage and greater visibility and are intended to be used when the worker is in an environment that poses a great risk to safety. ANSI Class 1 garments are intended to be used in situations of low safety risk.

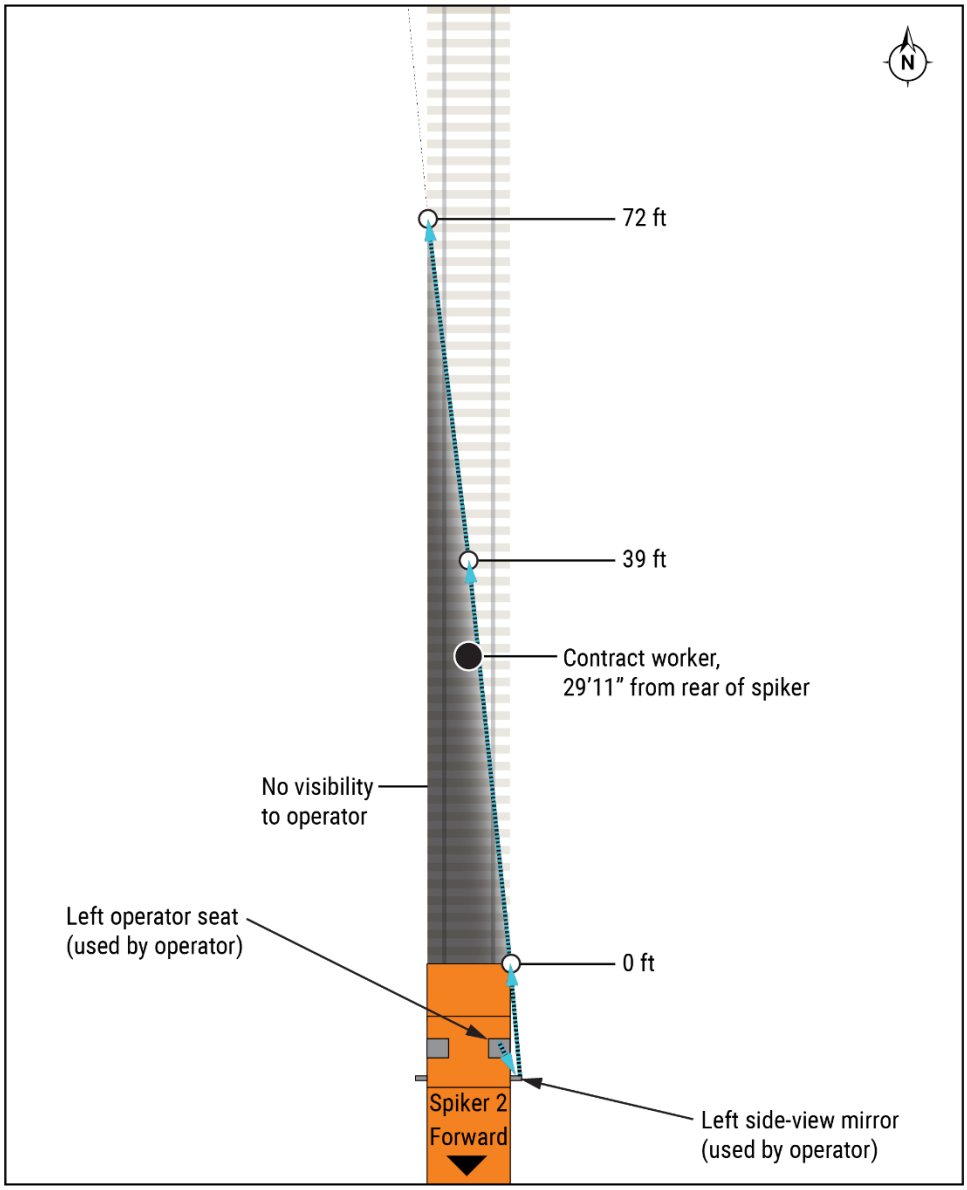

Figure 4. Diagram of sight distance observations for Spiker 2.

1.7.2 Change-of-Direction Alarm and Lights Testing

The NTSB conducted postaccident testing of the change-of-direction alarm system for each of the three spikers. The rear alarm speaker on Spiker 2 did not emit any sound. An examination revealed that the electrical plug for the speaker was disconnected. The speaker was plugged back in, and testing resumed.

The change-of-direction alarms on the spikers were designed to sound when the RMM's direction of travel was opposite the position of the toggle switch (indicating the machine had changed direction). Testing showed that on Spiker 2, the

change-of-direction alarm sounded when the direction of travel was the same as the position of the toggle switch; that is, when the toggle switch was in the forward position and the operator used the forward direction-of-travel pedal or when the toggle switch was in the reverse position and the operator used the reverse direction-of-travel pedal.[22] The full results of this testing for all three RMMs can be found in the below table.

Table. Change-of-direction alarm test results.

Toggle Switch Position	Direction of Travel	Expected Result	Spiker 1	Spiker 2	Spiker 3
Forward	**Forward**	No alarm	No alarm	Alarm—rear speaker	No alarm
Forward	**Reverse**	Alarm—rear speaker	No alarm	No alarm	Alarm—rear speaker
Center	**Forward**	Alarm—both speakers	Alarm—front speaker	Alarm—both speakers	Alarm—rear speaker
Center	**Reverse**	Alarm—both speakers	Alarm—front speaker	Alarm—both speakers	Alarm—rear speaker
Reverse	**Forward**	Alarm—front speaker	Alarm—front speaker	No alarm	No alarm
Reverse	**Reverse**	No alarm	No alarm	Alarm—front speaker	No alarm

Additional testing and observations were conducted on Spiker 2. The NTSB observed that the plug for the reverse direction-of-travel pedal was plugged into the input for the forward direction-of-travel pedal, and vice versa. Further, the plug for the reverse travel solenoid in the spiker's hydrostatic pump was plugged into the input for the forward travel solenoid, and vice versa.[23] A review of Nordco manufacturing records revealed that during quality assurance testing of the spikers in 2015, Nordco technicians documented what they called swapped travel pedal cables.[24] The reversed plugs for the hydrostatic pump solenoids were not documented.

[22] Postaccident testing also indicated that on Spiker 1, only the front speaker sounded an alarm, and on Spiker 3, only the rear speaker sounded an alarm.

[23] (a) A *hydrostatic pump* is a component of a nongeared transmission system. (b) A *solenoid* is a device that converts electrical energy to mechanical energy.

[24] Both before the accident and in postaccident testing, Spiker 2 traveled forward when the forward direction-of-travel pedal was pressed and vice versa.

When the pedal plugs and hydrostatic pump solenoid plugs were swapped and plugged into the correct locations, further testing was conducted. The Spiker 2 change-of-direction alarm system then operated as designed.

The NTSB reviewed NS's monthly maintenance records from January to October 2021 for the RMMs assigned to the R-12 rail gang. Records indicated that the nonworking change-of-direction alarm on Spiker 2 was not detected, documented, or remediated.

The NTSB conducted an examination of Spiker 2's change-of-direction lights. The lights worked as designed.

1.7.3 Horn System Testing

The NTSB tested the horn system on Spiker 2 that was used by the operator to provide an audible warning of the RMM changing direction. Only one of the two forward-facing trumpets and neither rear-facing horn trumpet produced an audible sound.

The NTSB contacted the local office of the Occupational Safety and Health Administration (OSHA) to conduct noise level testing. With both Spikers 2 and 3 operating on the track, the test operator of Spiker 2 sounded the horn in three short blasts; the sound was undetectable by OSHA's noise level measuring equipment. When the test operator sounded the horn continuously, OSHA's equipment measured the horn sound at 72.5 dBA and ambient noise of the RMMs at 71.5 dBA.[25]

In a postaccident interview with the NTSB, the Spiker 2 operator said that the horn was just above his head on the roof and that he could hear it when he tested it during the preshift inspection; he added that he believed someone standing 25 or 30 feet away would have been able to hear it too.

The NTSB disassembled the roof-mounted horn trumpets and observed that the internal components of the three nonworking trumpets were heavily corroded and rusted. Figure 5 shows the condition of the internal components of one of the nonworking trumpets. When new trumpets were connected to Spiker 2, they functioned correctly.

[25] See, for example, National Fire Protection Association (NFPA) 72, which states that notification appliances or alarms can adequately penetrate background noise and provide notification at "a sound level at the particular frequency or frequency bandwidth of at least 15 dB above the average ambient sound level" (NFPA 2022).

Figure 5. Internal components of a nonworking horn trumpet.

A review of Spiker 2 maintenance records from January to October 2021 showed that the inoperable roof-mounted trumpets had not been detected, documented, or remediated.

1.8 Postaccident Actions

1.8.1 Nordco

Following the accident, Nordco sent a product service bulletin to all of their customers providing instructions on testing change-of-direction alarms as well as on pedal configurations. Nordco also added information on the expected operation of change-of-direction alarms to the spiker operation manual (Nordco 2022). Nordco expanded the test track procedures before a spiker leaves the manufacturing facility to ensure that the change-of-direction alarm is functioning properly and that all pedals are connected properly.

1.8.2 National Salvage

National Salvage provided a standardized checklist to each rail division employee after the accident. The checklist informed them of the ANSI standards for

PPE and the required compliance with railroad regulations. National Salvage conducted two internal audits to check that PPE purchases made by employees on the company credit card met the required safety standards. The company further stated that project managers and safety directors will continue to review worker PPE during on-site job inspections to ensure compliance with railroad and ANSI standards.

1.8.3 Norfolk Southern Railway

After the accident, NS revised its training for all program maintenance supervisors and employees to facilitate understanding of PPE requirements and compliance with NS and ANSI standards. NS further stated that supervisors must make employees and contractors aware of the requirements and that contractors must train and supervise their employees on PPE requirements. NS also instructed all maintenance equipment supervisors to conduct a one-time inspection of the change-of-direction alarms in all spikers and provided a written procedure with inspection protocol.

NS further issued instructions to all program maintenance supervisors and employees that job safety briefings will include the geographic location of the job site in the event of an emergency. NS no longer depends on one person to be able to locate the site.

2 Analysis

2.1 Introduction

On December 8, 2021, an NS spiker RMM struck and killed a contract worker who was standing behind the spiker and within the gauge of the track when the operator of the RMM reversed direction on the track.

The analysis will discuss the following safety issues:

- Inaudible RMM horns and change-of-direction alarms.
- Inadequate inspection procedures of the machines equipped with these warning devices.
- Deficiency of and inadequate protection provided by NS's requirement for a 25-foot separation between workers and roadway maintenance machines.

The NTSB's review of the circumstances that led to this accident found the following areas either were not factors in or were not causal to the accident:

- *Fatigue, distraction, and drug or alcohol impairment*. A review of the 72-hour work and rest history for both the Spiker 2 operator and the contract worker showed no evidence of fatigue. Neither the operator nor the contract worker was using a cell phone at the time of the accident. Postaccident toxicological testing of the Spiker 2 operator and the contract worker were negative for alcohol or other drugs.
- *Emergency response*. Although there was some initial confusion about the location of the accident, emergency responders were on scene within 15 minutes of the accident. The contract worker was found deceased by emergency responders upon arrival.
- *Weather*. The weather did not affect visibility on the ground.
- *Contract worker's lack of appropriate PPE*. NS provided its employees and contractors with training on the use of PPE and the required ANSI standard. National Salvage also provided training to the contract worker about the appropriate PPE required by the railroad. The contract worker was not wearing any visible clothing that met ANSI Class 2 or higher standards as was required by safety rules. However, even if the contract worker had been wearing the appropriate level of PPE, he still would not have been visible to the spiker

operator at the time of the accident because of the spiker's visibility restrictions (discussed further below).

Therefore, the NTSB concludes that none of the following issues were causal to the accident: (1) fatigue, distraction, or impairment of either the Spiker 2 operator or the contract worker; (2) emergency response; (3) weather; or (4) the contract worker's lack of appropriate high-visibility PPE.

2.2 Accident Sequence

On the morning of the accident, following the job safety briefing, the Spiker 2 operator performed a walk-around inspection of the spiker as required by NS operating rules and found no issues. Once the work equipment was in place, the spikers began working from north to south. When Spiker 2 closed the gap with Spiker 1 ahead of it, the operator of Spiker 2 decided to reverse his machine to assist Spiker 3. He looked in his side-view mirror, did not see anyone standing behind the spiker, and blew the horn three times, following NS policy. He then reversed the spiker, and it struck the contract worker.

The operator of Spiker 2 was not immediately aware that the spiker had struck the contract worker. He looked down at the track and saw the worker underneath the spiker. The operator called for emergency services and shut down the machine. Emergency response units arrived on the scene and pronounced the contract worker deceased.

2.2.1 Inaudible Warning Devices

Audible warning devices are critical in a working environment that includes heavy equipment, as workers rely on these devices to know when it is safe to work and when it is not. Postaccident testing of Spiker 2 revealed that three of the four roof-mounted trumpets were rusted and heavily corroded and incapable of emitting any sound. Thus, the horn would not have been audible above the ambient noise of the working spikers at the time of the accident, providing no warning for the worker, who was standing more than 25 feet from the rear of the spiker.

The postaccident examination of Spiker 2 also found that the electrical connections between each direction-of-travel pedal and its corresponding hydrostatic pump solenoid input were swapped, but that this was misdiagnosed during factory quality assurance testing as swapped travel pedal cables. The travel pedal cables themselves were also found to be plugged into their opposite inputs. Although the accident spiker moved as directed by the direction-of-travel pedal, the

incorrect connections meant its change-of-direction alarm did not operate as designed.

The speaker for Spiker 2's automatic change-of-direction alarm was unplugged at the time of the accident, so no noise alerted the contract worker that the spiker was operating in reverse. When the speaker was plugged back in during postaccident testing of Spiker 2, the NTSB found that if the toggle switch was in the forward position and the spiker was traveling forward, the rear alarm would sound continuously, which would negate the intended function of the alarm. Thus, the NTSB concludes that the rear speaker for the spiker's change-of-direction alarm was deliberately disconnected to prevent it from sounding continuously when the spiker was traveling forward. Following the accident, Nordco, the spiker manufacturer, put controls in place both at the factory and in the operating manual for that spiker model to identify whether the change-of-direction alarm was functioning correctly. All of NS's Nordco spikers have been examined and repaired so that the change-of-direction alarm functions as designed.

Even if the change-of-direction alarm speaker had been plugged in, however, the incorrect pedal connections made at the factory meant that no alarm would have sounded in the reverse direction. Likewise, the spiker horn was inaudible above ambient noise. With neither the change-of-direction alarm nor the horn providing auditory alerts in the contract worker's direction above ambient noise, the worker would have been unaware of the spiker's movement toward him if he was not looking toward the machine. Therefore, the NTSB concludes that the contract worker was likely unaware that the spiker was reversing direction toward him because both the horn and the automatic change-of-direction alarm were not working properly and thus provided no warning to the worker.

Providing alerts in multiple modalities (visual and auditory) for all RMMs is important because someone working on or near railroad tracks may be focused elsewhere and may not see the machine's movement. Thus, the NTSB concludes that the functionality of both the horn and change-of-direction alarms is critical to safety on RMMs to alert workers of the equipment's direction of movement.

The preshift inspection performed by RMM operators is an opportunity to detect improper operation of the audible alerts on RMMs. Following NS policy, the operator of the accident spiker performed a preshift inspection that included checking the operability of the horn and the change-of-direction alarm. The operator reported that, while seated in the cab, he was able to hear the horn; however, the horn was positioned directly on top of the cab and thus was easier for him to hear. Postaccident noise level tests found that, at the worker's position just before the

accident, the horn would have been barely detectable above the ambient noise of the working spikers.

Although the operator of Spiker 2 did conduct an inspection of the RMM warning devices before starting work, he did not test for audibility at a distance. The NTSB concludes that NS's preshift inspection of the change-of-direction alarm and spiker horn was inadequate to identify if the alarm or any of the horn trumpets were not working properly, because the inspection did not consider whether someone standing at the spiker's standoff distance of 25 feet would be able to hear the alerts above ambient noise. Because similar audible alerts are used on other RMMs, the NTSB recommends that NS revise their preshift RMM inspection procedures to verify that the horns and change-of-direction alarms sound in the correct direction and are audible to someone standing at the RMM's standoff distance.

2.2.2 25-Foot Standoff Distance and Visibility Issues

As specialized equipment designed for track work, RMMs often have line-of-sight restrictions that are due to their design. In this accident, NS's established standoff rule required workers to stand a minimum of 25 feet behind RMMs. The contract worker was standing about 29 feet behind the RMM before it reversed direction, so he was outside the standoff limits and thus was following NS policy. But even at this distance, the Spiker 2 operator reported that he was not able to see the worker standing in the middle of the track gauge.

FRA regulations require that RMMs be equipped with rearward viewing devices. With one rear view mirror on each side, Spiker 2 complied with regulations. But the mirrors offered limited rearward visibility to the Spiker 2 operator. Sitting in the left-hand seat, the operator could only see out of the left side mirror with a large blind spot behind the RMM.

Postaccident sight distance testing revealed that someone standing in the middle of the track gauge would only become visible 39 feet from the rear of the spiker. Further, the Spiker 3 operator reported that the contract worker had not stood between Spikers 2 and 3 that day, so the Spiker 2 operator had no expectation that the worker would be in that location.

It is not uncommon for RMMs to move in reverse as part of normal work, so rearward visibility for operators is critical. As identified in this accident, rear view mirrors can provide limited visibility behind an RMM. However, safety technology has advanced sufficiently that rearward visibility can be enhanced through other means, such as backup cameras, which offer a constant rearward view of surroundings for

operators during reverse movements. This provides the RMM operator with a view of the area directly behind the machine that would otherwise be in the operator's blind spot. The NTSB concludes that had Spiker 2 been equipped with a functioning backup camera, the operator would have been able to detect the contract worker before reversing the machine.

Roadway maintenance machines are in use throughout the North American rail network—on Class I railroads, on short line and regional railroads, and by smaller rail-related companies. In addition to purchasing new RMMs, the railroad industry rebuilds or remanufactures RMMs already in use.[26] The FRA allows but does not require the use of backup cameras to satisfy the requirements of 49 *CFR* 214.509 (FRA 2003, p. 44396). The NTSB believes that the use of backup cameras on RMMs would improve rearward visibility for RMM operators by reducing or eliminating the blind spots behind the machines. The NTSB is also aware that backup camera technology is an available safety system offered by multiple RMM manufacturers and is already in use on some RMMs. Therefore, the NTSB recommends that the FRA require all newly manufactured and all rebuilt and remanufactured RMMs to be equipped with backup cameras.

The NTSB acknowledges that the pace of rulemaking can be time consuming and believes that in the interim, earlier implementation of backup camera technology on new RMMs and those already in use would reduce the chances of a similar accident by providing operators a constant rearward view of their surroundings. Further, as stated above, the technology exists. Therefore, the NTSB recommends that all Class I railroads equip new and existing RMMs with backup camera technology.

The American Short Line and Regional Railroad Association (ASLRRA) represents the owners and operators of short line and regional railroads throughout North America.[27] Many ASLRRA member companies may use RMMs in their operations. The NTSB believes that these member companies would benefit from learning about the circumstances of this accident and the importance of equipping new and existing RMMs with backup camera technology. Therefore, the NTSB

[26] The FRA has previously defined "rebuilt" and "remanufactured" in rulemaking, in reference to railroad equipment. See, for example, 49 *CFR* Part 223 "Safety Glazing Standards" and 49 *CFR* Part 229 "Locomotive Safety Standards."

[27] The more than 1,000 companies represented by the ASLRRA include Class II and III railroads; railroads that provide railroad switching, terminal, and tourist or excursion services; and companies that supply goods and services to the short line industry.

recommends that the ASLRRA inform its members of the circumstances of this accident and the importance of equipping new and existing RMMs with backup camera technology.

Although it is incumbent upon workers and RMM operators to maintain the 25-foot standoff distance, the NTSB is concerned that this distance may not be sufficient for all machines. As in this case, anyone standing between less than 39 feet from the rear of the spiker in the middle of the track gauge would not be visible to the operator. So, even if a worker were following the 25-foot rule, an operator may still be unable to see them, as likely occurred in this accident.

Ensuring that workers who may be in the gauge of the track are visible to RMM operators offers another layer of safety to workers and operators. Although auditory alarms are critical, they were not operational in this accident, so the contract worker likely was not aware the spiker was moving closer to him such that he ended up in violation of the 25-foot rule. Because all RMMs are built differently, a fixed standoff distance of 25 feet may not be sufficient for some machines, such as the accident spiker. The NTSB concludes that NS's 25-foot standoff distance rule is inadequate to ensure that operators can see roadway workers who are standing more than 25 feet behind an RMM, because it does not consider the unique design and visibility limitations of each RMM.

Title 49 *CFR* 214.341 (a) (5) states that railroads must establish specific provisions for "space between machines and roadway workers to prevent personal injury." NS's 25-foot standoff distance rule did not ensure the space between the spiker and roadway worker was sufficient. For RMMs already in use that are not equipped with backup cameras, the issue of rearward visibility remains. Therefore, the NTSB recommends that NS revise its RMM standoff distance rule based on the different types of RMMs to ensure operators have clear visibility of roadway workers in front of and behind the machines. Because the issue of visibility behind RMMs is not limited to NS, the NTSB believes that other railroads also need to evaluate and revise as necessary the standoff distances of all their RMMs. Therefore, the NTSB recommends that the FRA issue a safety alert to railroads regarding the importance of establishing RMM standoff distances that take into account the ability of an operator to see a worker or object in the track gauge behind an RMM.

3 Conclusions

3.1 Findings

1. None of the following safety issues were causal to the accident: (1) fatigue, distraction, or impairment of either the Spiker 2 operator or the contract worker; (2) emergency response; (3) weather; or (4) the contract worker's lack of appropriate high-visibility personal protective equipment.

2. The rear speaker for the spiker's change-of-direction alarm was deliberately disconnected to prevent it from sounding continuously when the spiker was traveling forward.

3. The contract worker was likely unaware that the spiker was reversing direction toward him because both the horn and the automatic change-of-direction alarm were not working properly and thus provided no warning to the worker.

4. The functionality of both the horn and change-of-direction alarms is critical to safety on roadway maintenance machines to alert workers of the equipment's direction of movement.

5. Norfolk Southern Railway's preshift inspection of the change-of-direction alarm and spiker horn was inadequate to identify if the alarm or any of the horn trumpets were not working properly, because the inspection did not consider whether someone standing at the spiker's standoff distance of 25 feet would be able to hear the alerts above ambient noise.

6. Had Spiker 2 been equipped with a functioning backup camera, the operator would have been able to detect the contract worker before reversing the machine.

7. Norfolk Southern Railway's 25-foot standoff distance rule is inadequate to ensure that operators can see roadway workers who are standing more than 25 feet behind a roadway maintenance machine, because it does not consider the unique design and visibility limitations of each roadway maintenance machine.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Reed, Pennsylvania, accident was the inability of the spiker operator to see the contract worker behind the spiker and the contract worker not being alerted by the spiker's nonfunctional horn and change-of-direction alarms. Contributing to the accident was (1) Norfolk Southern Railway's preshift inspection that did not check the audibility of the spiker's alerts above ambient noise; (2) Nordco Inc. allowing the spikers to leave the factory without assuring the change-of-direction alarm was working; and (3) insufficient standoff distance chosen by Norfolk Southern Railway that did not provide adequate visibility behind the spiker.

4 Recommendations

New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the Federal Railroad Administration:

Require all newly manufactured and all rebuilt and remanufactured roadway maintenance machines to be equipped with backup cameras. (R-23-22)

Issue a safety alert to railroads regarding the importance of establishing roadway maintenance machine standoff distances that take into account the ability of an operator to see a worker or object in the track gauge behind a roadway maintenance machine. (R-23-23)

To all Class I Railroads:

Equip new and existing roadway maintenance machines with backup camera technology. (R-23-24)

To Norfolk Southern Railway:

Revise your preshift roadway maintenance machine inspection procedures to verify that the horns and change-of-direction alarms sound in the correct direction and are audible to someone standing at the roadway maintenance machine's standoff distance. (R-23-25)

Revise your roadway maintenance machine standoff distance rule based on the different types of roadway maintenance machines to ensure operators have clear visibility of roadway workers in front of and behind the machines. (R-23-26)

To the American Short Line and Regional Railroad Association:

Inform your members of the circumstances of this accident and the importance of equipping new and existing roadway maintenance machines with backup camera technology. (R-23-27)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY

Chair

BRUCE LANDSBERG

Member

MICHAEL GRAHAM

Member

THOMAS CHAPMAN

Member

Report Date: November 14, 2023

Appendixes

Appendix A: Investigation

The National Transportation Safety Board was notified of this accident on December 8, 2021. Members of the investigative team arrived on scene on December 9, 2021. The National Transportation Safety Board team consisted of an investigator-in-charge, a mechanical investigator, a track investigator, and a human performance investigator. The Federal Railroad Administration, Norfolk Southern Corporation, National Salvage and Service Corporation, and the Brotherhood of Maintenance of Way Employes Division were parties to the investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Federal Railroad Administration:

R-23-22

Require all newly manufactured and all rebuilt and remanufactured roadway maintenance machines to be equipped with backup cameras.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2, 25-Foot Standoff Distance and Visibility Issues. Information supporting (b)(1) can be found on page 20; (b)(2) is not applicable; and (b)(3) is not applicable.

R-23-23

Issue a safety alert to railroads regarding the importance of establishing roadway maintenance machine standoff distances that take into account the ability of an operator to see a worker or object in the track gauge behind a roadway maintenance machine.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2. Information supporting (b)(1) can be found on page 21; (b)(2) is not applicable; and (b)(3) is not applicable.

To all Class I Railroads:

R-23-24

Equip new and existing roadway maintenance machines with backup camera technology.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2. Information supporting (b)(1) can be found on page 20; (b)(2) is not applicable; and (b)(3) is not applicable.

To Norfolk Southern Railway:

R-23-25

Revise your preshift roadway maintenance machine inspection procedures to verify that the horns and change-of-direction alarms sound in the correct direction and are audible to someone standing at the roadway maintenance machine's standoff distance.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.1. Information supporting (b)(1) can be found on page 19; (b)(2) is not applicable; and (b)(3) is not applicable.

R-23-26

Revise your roadway maintenance machine standoff distance rule based on the different types of roadway maintenance machines to ensure operators have clear visibility of roadway workers in front of and behind the machines.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2. Information supporting (b)(1) can be found on page 21; (b)(2) is not applicable; and (b)(3) is not applicable.

To the American Short Line and Regional Railroad Association:

R-23-27

Inform your members of the circumstances of this accident and the importance of equipping new and existing roadway maintenance machines with backup camera technology.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.2.2. Information supporting (b)(1) can be found on page 20–21; (b)(2) is not applicable; and (b)(3) is not applicable.

Appendix C: Special NTSB Investigation

In March 2023, the National Transportation Safety Board (NTSB) announced that it would conduct a special investigation of Norfolk Southern Railway's (NS) organization and safety culture. The NTSB urged NS to take immediate action to review and assess its safety practices with the input of employees and others and implement necessary changes to improve safety.

The NTSB is also investigating the following five accidents involving NS in addition to the Reed, Pennsylvania, investigation:

- Bessemer, Alabama (RRD23LR003)
- East Palestine, Ohio (RRD23MR005)
- Anniston, Alabama (RRD23LR008)
- New Castle, Pennsylvania (RRD23FR011)
- Elliston, Virginia (RRD23FR013)

References

FRA (Federal Railroad Administration). 2003. 49 *CFR* Part 214, Roadway Maintenance Machine Safety; Final Rule. 68 Fed. Reg. 144 (July 28, 2003).

NFPA (National Fire Protection Association). 2022. *NFPA 72: National Fire Alarm and Signaling Code*, section A.18.4.4.1 (October 25, 2021).

Nordco (Nordco Inc.). 2022. *SE Spiker Operation Manual*, *5: Operator System & Controls Familiarization* (February 2022).

NS (Norfolk Southern Railway). 2019. *Operating Rules, 818(d): Proper Spacing Between On-Track Equipment, Roadway Maintenance Machines, and Employees* (January 1, 2019).

-----. 2019a. *Operating Rules, 802: Equipment Inspection* (January 1, 2019).

-----. 2019b. *Safety and General Conduct Rules, 1044: High-Visibility Safety Garments* (January 1, 2019).

The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in the other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties … and are not conducted for the purpose of determining the rights or liabilities of any person" (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)).

For more detailed background information on this report, visit the NTSB Case Analysis and Reporting Online (CAROL) website and search for NTSB accident ID RRD22LR003. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting –

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