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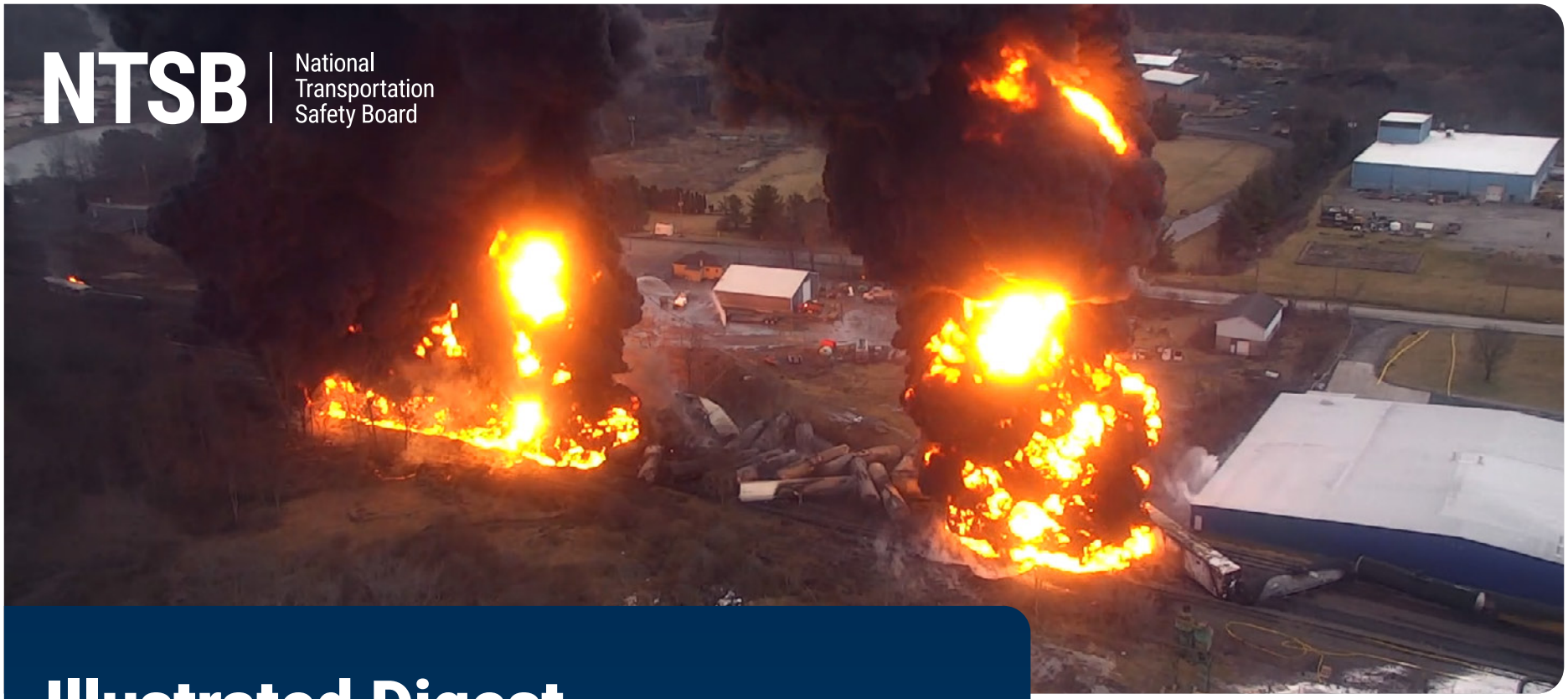


Illustrated Digest

Norfolk Southern Railway Derailment and Subsequent Hazardous Materials Release

East Palestine, Ohio • February 3, 2023

This illustrated digest is a companion to the National Transportation Safety Board's (NTSB's) Accident Report NTSB/RIR-24-05. It provides a description of the accident and subsequent actions, discusses safety issues, and outlines the safety recommendations found in the full report. This digest is not intended to supersede the full report, and in case of any contradiction or apparent contradiction, the full report serves as the NTSB's definitive publication on the derailment.

The full report and docket are available on **www.ntsb.gov**.

Accident overview

At 10:14 p.m. on February 1, 2023, a Norfolk Southern Railway (NS) train departed the Terminal Railroad Association of St. Louis yard in Madison, Illinois, bound for the Conway Yard in Conway, Pennsylvania. It never arrived. Two days later, on February 3, 2023, at about 8:54 p.m., an overheated wheel bearing caused an axle to "burn off," and 38 cars derailed in East Palestine, Ohio. Eleven of those derailed cars carried hazardous materials.

Of those 11 derailed hazardous materials cars, three carrying flammable and combustible liquids were cracked or punctured during the derailment and released some contents. The tank cars that were breached as they derailed were DOT-111 tank cars. (*See* The long and limited phaseout, *p.3.*)

A fire broke out during the derailment, fed by the spilled flammable and combustible liquids. It spread to other tank cars and freight cars. But that was not the only hazardous materials release.

Five pressurized DOT-105 tank cars carrying the hazardous material vinyl chloride (VCM) survived the initial derailment intact; however, four of the five were exposed to fires, and the next day, their pressure relief devices (PRDs)–a tank car safety feature–released some VCM. (*See* Pressure relief devices, *p. 7.*) The sixth DOT-105 car, which was carrying isobutylene, derailed but did not breach. It wasn't exposed to fires and wasn't involved in the vent and burn process.

On February 6, 2023, the incident commander, at the urging of NS and its contractors, approved a vent and burn procedure. NS contractors then used explosives to puncture (vent) the tank cars and simultaneously ignite (burn) the remainder of the VCM on scene, including from the car that had not released any contents through its PRD. (*See* The vent and burn decision, *p.10.*)

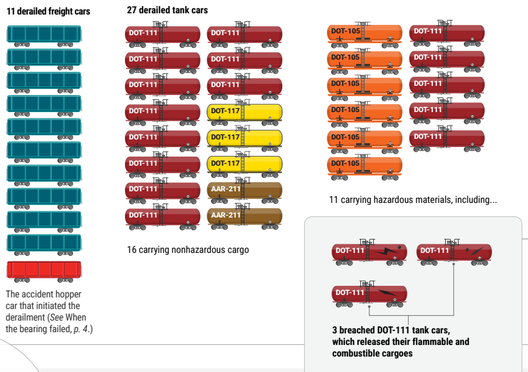
Punctured DOT-111 tank car that released butyl acrylates, a flammable liquid, likely starting the postderailment fires.

THE TRAIN AT THE TIME OF THE DERAILMENT

3 locomotives

149 mixed-freight cars → **38** of which derailed

In all, the accident train weighed **17,977 tons** and was **9,309 feet long**



DOT-111 tank cars in a derailment: flip a coin

In a derailment, DOT-111 tank cars fail about as often as a coin comes up heads when you flip it.

The NTSB's 1991 safety study, *Transport of Hazardous Materials by Rail* found that 54% of DOT-111 tank cars involved in accidents in 1988–1989 were breached and released some or all of their contents.

More than 30 years later, we saw a similar breach rate at East Palestine: 8 of 16 derailed DOT-111s released at least some of their contents, with a breach rate of 44% from confirmed mechanical damage.

Does the tougher DOT-117 standard help?

From 2013 through 2023, the NTSB investigated 17 accidents in which damaged DOT-111 and CPC-1232 tank cars (DOT-111 tank cars built to additional industry standards) released hazardous materials. In 15 of these accidents (88%), the hazardous materials release likely would have been mitigated by the use of a more robust tank car, such as the DOT-117, with a thicker tank shell **(A)** and consistent use of full-height head shields **(B)**. In East Palestine, three DOT-117 tank cars transporting nonhazardous materials derailed but remained intact.

The best outcome is no derailment at all. But when tank cars carrying hazardous materials do leave the track, they should maintain their structural integrity.

The long and limited phase-out

The Fixing America's Surface Transportation (FAST) Act allows flammable liquids in packing groups II and III, like the butyl acrylates released through a punctured DOT-111 tank car in the East Palestine derailment, to be carried in DOT-111 tank cars through May 2029. The law allows for extensions until 2031. Rather than risk slow implementation of a too-long schedule (possibly followed by an extension), the NTSB recommends expediting the deadline and adding scheduled milestones.

Combustible liquids catch fire at higher temperatures than flammable liquids, but can still fuel fires. Two other DOT-111 cars released combustible liquids through cracks or punctures in East Palestine. There is currently no requirement to ship combustible liquids in DOT-117s. The NTSB recommends phasing out the use of DOT-111s and similar cars from all hazardous materials transportation. (*See* Recommendations, *p. 15.*)

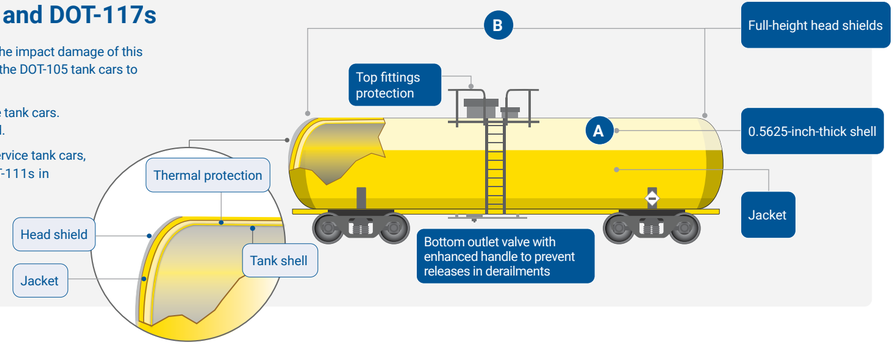
DOT-105s, DOT-111s, and DOT-117s

DOT-105s are tough, pressure tank cars. The impact damage of this derailment did not challenge the ability of the DOT-105 tank cars to contain their cargo.

DOT-111s are nonpressure general service tank cars. Sometimes specific protections are added.

DOT-117s are also nonpressure general service tank cars, but offer improved survivability over DOT-111s in derailments and fire conditions.

DOT-117 tank cars must meet the same thermal survivability performance requirements as pressure tank cars, such as DOT-105s.



When the bearing failed

The East Palestine derailment began when an overheated bearing burned off the accident hopper car. Here is what you need to know about bearings, hot bearing detectors (HBDs), and what happened when the accident hopper car passed over the final three HBDs of the journey in the Ohio towns of Sebring, Salem, and East Palestine.

All about bearings

Bearings 101

A bearing **(A)** fits around the end of a railcar axle. The part of the axle extending into the bearing is called the journal **(B)**. The bearing's roller components allow the journal to turn within the bearing with little friction. However, when a bearing fails, the resulting friction can be catastrophic. In East Palestine, the journal's cylindrical shape was worn down to a cone **(C)**. (*See* box *below*.)

Hot bearing detectors

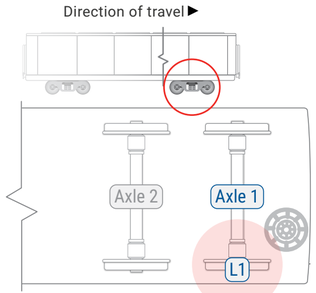
Overheated wheel bearings are the most common mechanical or electrical cause of rail accidents. Because overheated bearings are so dangerous, railroad tracks are equipped with HBDs, devices located along the track that measure the bearing's temperature relative to the ambient temperature **(D)**. Ambient temperature means the temperature outside. For example, the ambient temperature at Sebring, Ohio, was measured by a thermometer at the nearby signal bungalow.

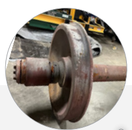
Bearings can go from below-alarm temperature to seized in less than a minute. In this accident, however, fire was first photographed near the L1 bearing by a surveillance camera in Salem, Ohio (right), 39 minutes before the train derailed in East Palestine.

The L1 bearing

The bearing that caused the accident hopper car to derail was its **L1** bearing, which is on the right side of the car, facing the direction of travel.

Railcar axles are numbered starting from the end of the railcar with the brake wheel (the "B end"). When the B end is in the front of the car (when it faces the direction of travel) the "left-side" wheels and bearings are on the right.

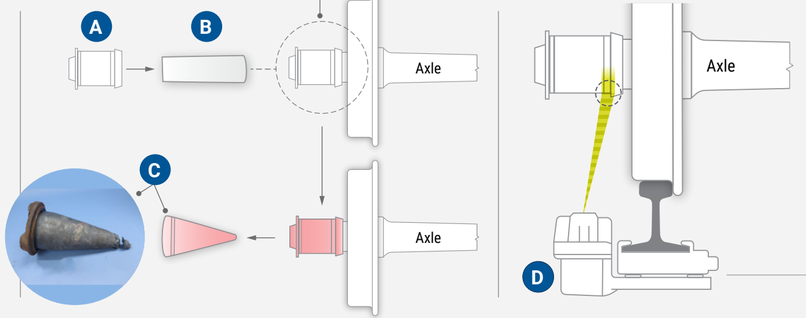




The undetected hot bearing burns off

1. HBDs **(D)** measure the temperature on the outside of the bearing cup. When a bearing heats up inside, it may take 30-60 minutes for the HBD to sense it from the outside. The HBD in Salem measured a temperature of only 103° above ambient, despite the fact that the bearing was on fire. So, it generated an alert to the Wayside Help Desk, not an alarm to the train crew.

2. By the time the alarm sounded at the East Palestine HBD, the journal was worn down to a cone, and it was too late. The hopper car and 37 others derailed as the train's emergency braking system activated.



On fire but not "critical"

Sebring

At 7:37 p.m., at the Sebring HBD, the reading for the L1 bearing was only **38°F above ambient**—not high enough to trigger an alert. The R1 bearing measured 20°F above ambient. But the L1 bearing was hotter.

Salem

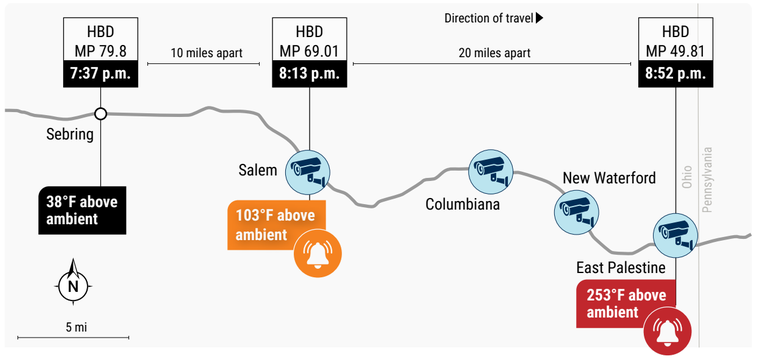
At 8:13 p.m., at the Salem HBD, the reading for the L1 bearing was **103°F above ambient**. This reading was high enough to trigger a noncritical alert to the Wayside Help Desk (*see box*), but not to the crew. A surveillance camera picture from Salem showed fire near the bearing (*right*). Surveillance cameras in Sebring also captured images of the train, and no anomalies were noted.

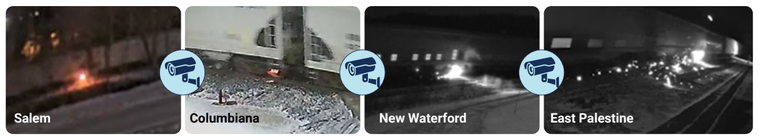
East Palestine

About 8:52 p.m., the train went over the East Palestine HBD. Less than a minute later, the HBD recorded a temperature of **253°F above ambient** at the L1 bearing; bearing R1 remained at 20°F above ambient. The HBD immediately transmitted a critical alarm, which was broadcast in the locomotive cab.

Under NS rules, if a train's crew hears a critical alarm, they must stop the train right away and inspect the wheelset that triggered the alarm. The engineer began to slow the train before 8:54 p.m.

But it was too late; the hopper car and 37 others derailed as the train's emergency braking system activated.





The Wayside Help Desk

The Wayside Help Desk in Atlanta, Georgia, monitors alerts from NS's HBDs. Critical alarms broadcast straight to the train crew. For noncritical alerts, the analyst monitors the train over HBDs it crosses later, paying attention to temperature trends. The single analyst on duty did not notice the Salem noncritical alert, as he dealt with higher-priority alerts. But if he did notice the alert, that would not have prevented the derailment. The analyst said that if he had seen the Salem HBD alert in real time, he would have followed NS rules and watched for alerts from HBDs it went over later. The next HBD the accident train went over was in East Palestine.

In the East Palestine derailment, the alarm was received by the lead locomotive radio and broadcast over the in-cab speakers: "**Critical alarm, critical alarm, critical alarm. Norfolk Southern milepost 49.8, track 1 hotbox, axle 101, south rail.**"

Derailment and response: February 3–4

After the accident hopper car's L1 bearing burned off, 38 railcars derailed. Three DOT-111 tank cars, carrying flammable and combustible liquids, spilled their contents, igniting fires. First responders struggled against mounting challenges, and five intact cars carrying vinyl chloride heated up. Here is a timeline of key events.

Evening, February 3

8:54 p.m. 38 railcars derail, including 27 tank cars, 11 of which are carrying hazardous materials. Three DOT-111 tank cars fail, releasing flammable or combustible material.

A fire breaks out, likely due to butyl acrylates released from a punctured DOT-111 tank car.

Five derailed cars are intact DOT-105 tank cars carrying VCM. Four out of the five are ultimately exposed to postderailment fires.

8:56 p.m. First 911 calls reach the East Palestine Fire Department (EPFD) dispatch.

9:00 p.m. East Palestine first responders arrive at the scene to find what they later describe as fires burning along the length of the derailment pileup. Deputy fire chief, in command while the chief is on leave, establishes the first command post near the derailment. Firefighters spray water, which does not suppress the fires.

9:04 p.m. East Palestine dispatch requests consist information from NS.

9:53 p.m. Residents within 1 mile advised to shelter in place.

10:00 p.m. Nearly an hour after the request, NS transmits consist to Columbiana County Emergency Management Agency (CCEMA) director. (*See* Hazard communications and guidance, *right*.)

11:00 p.m. Residents within 1 mile ordered to evacuate.

NS hazardous materials personnel reach the scene, followed by contractors. The president of one NS contractor, Specialized Professional Services, Inc. (SPSI), later noted there was a fire in a ditch south of the track, and that he smelled the distinctive odor of acrylates.

Around 12:00 a.m., Feb. 3–4. NS regional manager advises deputy fire chief to relocate command post to fire and police station. Deputy fire chief agrees, and relocation begins. Relocation is complete about 2:00 a.m. Feb. 4.

Hazard communications and guidance

Safe transportation of hazardous materials depends on a system of hazard communications. Emergency responders rely on this system to take the most effective action and to protect their own safety. Other guidance and information can also be critical.

A key source of information is the train's consist (its car-by-car makeup). At the scene of a hazardous materials release, responders often get the consist electronically from the railroad operating the train.

Emergency responders also rely on the Pipeline and Hazardous Materials Safety Administration's (PHMSA's) Emergency Response Guidebook (ERG) and other guidance and information. In East Palestine, these included the safety data sheet (SDS) that Oxy Vinyls published on VCM, and The Chlorine Institute's Pamphlet 171, which discusses VCM polymerization (*see* Polymerization, *p. 8*).

Lapses

- Placards on tank cars became illegible due to fire.
- Responders asked NS for the consist at about 9:04 p.m. NS did not provide it until shortly before 10 p.m.
- Written guidance and information about chemical hazards was misleading.

Diamond-shaped placards are required on each side and each end of a rail car carrying hazardous materials. They show at a glance which of the nine classes of hazardous materials is present. An identifying number must also be displayed, within the diamond or in a separate rectangular placard, specifying which of the thousands of hazardous materials is being carried.

Morning, February 4

Around 12:00 a.m., Feb. 3–4, the PRD on one VCM tank car activates; others will follow. PRD cycling continues on the four fire-exposed tank cars until midafternoon Feb. 4.

7:54 a.m. An NS hazardous materials officer calls CHEMTREC—a third-party company that operates a 24-hour call center for emergencies involving hazardous materials—requesting a copy of the SDS and a call back.

8:22 a.m. CHEMTREC contacts Oxy Vinyls and facilitates communication with NS.

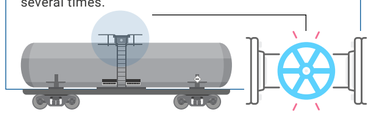
Evening, February 4

5:30 p.m. One tank car's PRD actuates at 5:30 p.m. after around 2 hours without activity. It vents more energetically than the other cars for about 70 minutes before finally reclosing for good. SPSI, an NS contractor, interprets the energetic PRD activity to mean that polymerization had occurred. (*See* Polymerization, *p. 9*, The vent and burn decision, *p. 10*.)

6:00 p.m. In a conference call with NS and SPSI, Oxy Vinyls assesses a low probability of polymerization but recommends monitoring tank car temperatures.

Pressure relief devices

PRDs are spring-loaded valves designed to release material if the pressure in a tank car rises above a certain threshold. The PRD opens until the tank's pressure falls low enough for the valve to reclose. A tank car exposed to a pool fire may repeat this cycle several times.



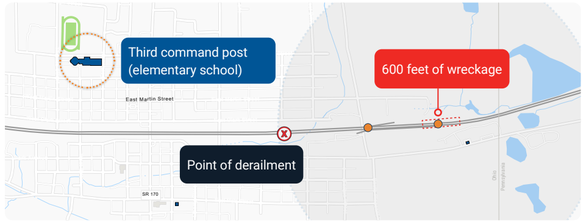
Derailment and response: February 5–6

By the morning of Sunday, February 5, the command post is relocated a second time to a public school more than a mile from the derailment site to accommodate all necessary personnel. With no further PRD actuations, NS and its contractors continue to assess the possibility of polymerization.

What is polymerization?

Polymerization is the process by which relatively small molecules (monomers) combine chemically to create larger chain- or network-like molecules (polymers). VCM polymerizes into polyvinyl chloride (PVC), a hard plastic. Polymerization produces heat, and NS and contractor personnel discussed this leading to a boiling liquid expanding vapor explosion, or BLEVE.

However, as long as stabilized VCM remains in unbreached DOT-105 tank cars, it does not have enough oxygen to support polymerization. The NTSB has never found evidence of polymerization in a VCM release from a tank car. PHMSA's hazardous materials Incident Database has only five reports of polymerization involving stabilized VCM since 1971—the reports NS filed for the cars in East Palestine, which were breached by explosives during the vent and burn, not by polymerization.



What happened to each derailed car

At right, you can see the fate of the derailed cars. All of the DOT-117 (yellow, black labels) tank cars resisted damage and did not spill their contents. Three DOT-111 tank cars (**A-C**) did release their flammable and combustible contents through punctures and/or cracks from the derailment, releasing flammable or combustible liquids.

Five DOT-105 cars carrying VCM (**D-H**) survived the derailment without punctures or tears but contractors vented and burned their contents 3 days later. Four of them had withstood fires without cracks or punctures, even though their PRDs activated and vented some contents.

What is going on inside the VCM cars?

The initial 2- to 3-hour pool fire that burns in the ditch alongside the derailment is likely fueled by butyl acrylates from tank car **(A)** in the diagram. Other candidates include the two other red tank cars in the diagram, which carry combustible liquids **(B and C)**.

This leads to more fires involving spills from other tank cars and freight car commodities, such as plastic pellets. These fires expose VCM tank cars (**D through H**) to heat, resulting in PRDs activating (*see pages 6–7*).

On February 5, when the PRD activity has stopped, contractors find traces of a volatile organic compound near one VCM tank car. SPSI's president believes that the PRD is plugged with PVC, the result of polymerization.

On February 6, NS and its contractors tell the rest of the incident command that the heated VCM could undergo polymerization and cause a BLEVE. (*See* The vent and burn decision, *p. 10.*)

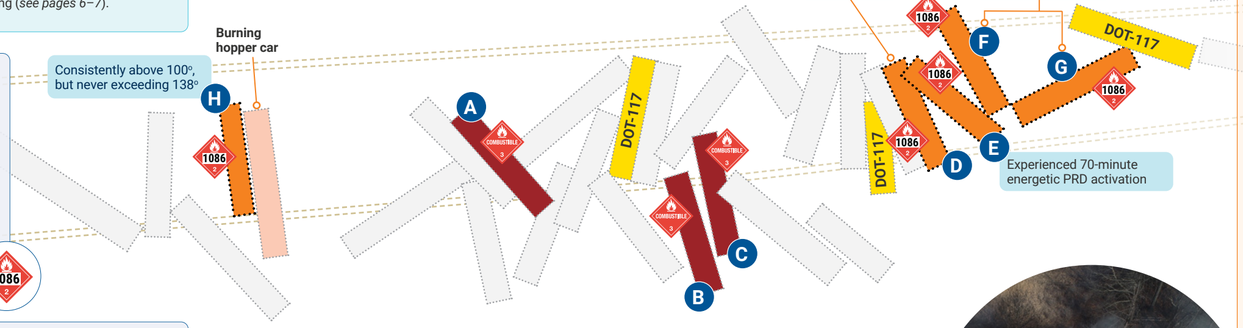
On February 5, representatives from Oxy Vinyls meet with SPSI and SRS personnel. Oxy Vinyls states that a temperature above 185°F could actuate a PRD but not introduce oxygen into the tank and destabilize the VCM.

NS and its contractors continue to respond to the situation as though the VCM is polymerizing. But is it?

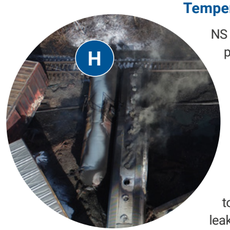
The temperatures of the five cars, measured on February 5 and 6, do not approach the 185 °F that caused the initial PRD actuations, and temperature trend was even declining (*see* charts *at right*).

What polymerization would look like

The Chlorine Institute's Pamphlet 171, a guidance source used on scene, overstates the danger of polymerization. What would polymerization look like? A spike in temperature is one symptom. At Oxy Vinyls' suggestion, SPSI and SRS collect VCM tank car temperatures on February 5–6, 2023.



Temperature and pressure in the VCM cars



NS contractors tried to measure the VCM cars' internal pressures on February 4 and 5, but could not measure the pressure of cars exposed to pool fires. The pressure in the car that was not exposed to pool fires was stable. None of the tank cars was releasing VCM except through PRDs.

Also on February 4 and 5, NS contractors noted no signs of gas being released from the car that was resting against the burning hopper car **(H)**, though a gas detector indicated the presence of volatile compounds near the top of the car. SPSI's president believed that VCM was leaking from this car, but that polymerization inside the car was preventing it from releasing at large enough quantities to catch fire.

Temperature monitoring

Most temperatures were in the 60s—room temperature. Other than the VCM tank car at the western edge of the pileup **(H)**, only two readings, both at 7:00 a.m. February 6, were warmer; one was 90° and another was 115°. After that time, only tank car **(H)** was warmer than room temperature. No car was warmer than 139°.

Tank car temperatures, February 5

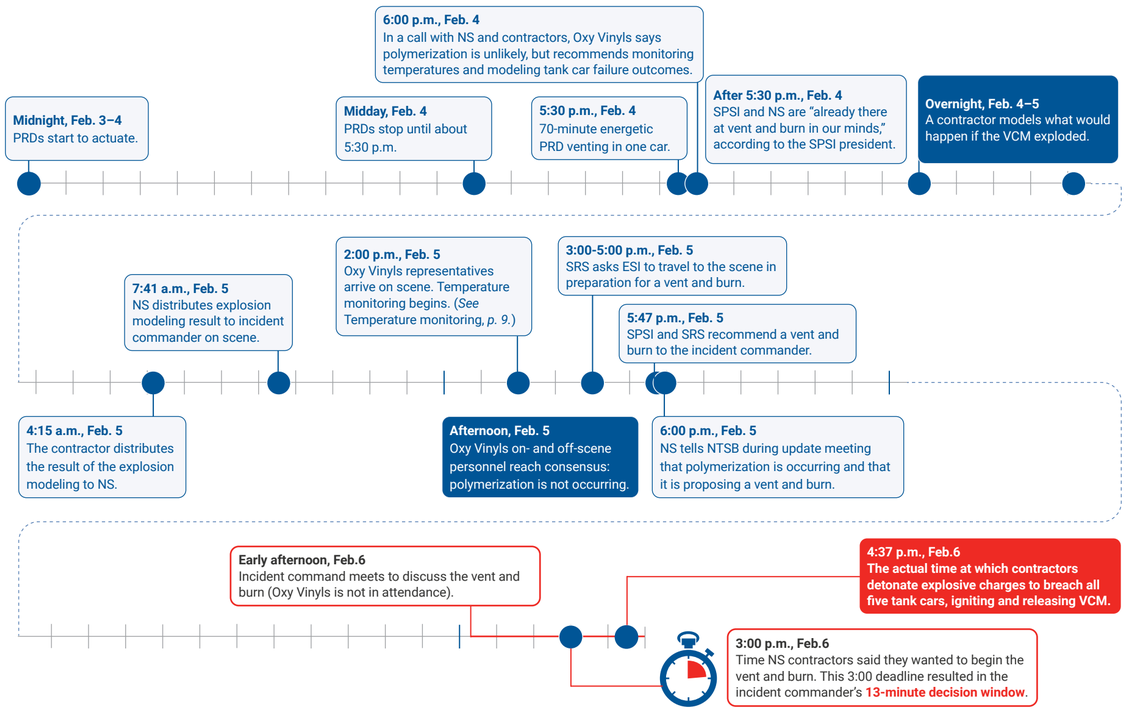
	D	E	F	G	H
4:00 p.m.	67°	65°	65°	65°	135°
5:00 p.m.					138°
6:00 p.m.					136°
7:00 p.m.					136°
8:00 p.m.					130°
9:00 p.m.					130°
10:00 p.m.					130°
11:00 p.m.					131°
12:00 a.m.	67°	65°	65°	65°	139°

Tank car temperatures, February 6

	D	E	F	G	H
1:00 a.m.	67°	65°	65°	65°	129°
2:00–4:00 a.m.	↓	↓	↓	↓	↓
7:00 a.m.	115°	90°	63°	62°	120°
8:37 a.m.	65°	65°	65°	62°	127°
9:30 a.m.	65°	65°	65°	65°	126°
10:30 a.m.	65°	65°	65°	65°	126°
11:30 a.m.	65°	65°	65°	65°	126°
12:30 p.m.	65°	65°	65°	65°	126°
1:30 p.m.	67°	65°	65°	65°	126°
2:30 p.m.	67°	65°	65°	65°	126°

The vent and burn decision

NS and its contractors advocated for a vent and burn to prevent an explosion caused by polymerization. Oxy Vinyls said polymerization was not occurring. On February 6, the incident commander was given **13 minutes to decide what to do**, but was only presented with one viewpoint.



NS and its contractors

On scene, NS and its contractors relied on guidance that included misleading information about signs of polymerization. (*See* Hazard communication and guidance, *p.6*, What is polymerization?, *p. 8.*)

Shortly after midnight February 3–4, PRDs on the VCM tank cars began to actuate (*see* Pressure relief devices, *p. 7*), then vented material on and off until the next afternoon. At first, NS and its contractors considered flaring and hot tapping to remove the contents of the intact VCM cars (*see* Alternatives to vent and burn, *p. 12*).

On February 4 at 5:30 p.m., when a PRD started energetically releasing VCM then stopped 70 minutes later, the president of SPSI said he interpreted it to mean that the VCM had polymerized, increasing tank pressure and "gumming up" the PRD. After that, he said, SPSI and NS "were already there at vent and burn in our minds."

Oxy Vinyls weighs in

At 8:22 a.m. February 4, NS was put in touch with Oxy Vinyls, the manufacturer and shipper of the VCM. At 6:00 p.m., NS and SPSI first communicated directly with Oxy Vinyls in a conference call. (*See* Evening, February 4, *p. 7.*)

Oxy Vinyls said polymerization probably was not happening and recommended monitoring temperatures. (*See* Temperature monitoring, *p. 9.*)

On February 5, Oxy Vinyls representatives arrived and told SRS and SPSI personnel that a temperature above 185°F could actuate a PRD but not introduce oxygen into the tank (oxygen is necessary for polymerization). But, NS and its contractors continued to respond as though the VCM was polymerizing. SPSI and SRS contacted the incident commander and said that circumstances might require a vent and burn.

While NS and its contractors advocated for the vent and burn, Oxy Vinyls representatives on site called the Oxy Vinyls team in Dallas and came to a consensus that evidence did not support polymerization. But, by the time Oxy Vinyls met with SPSI at 7:00 p.m. on February 5, NS had begun preparations for the vent and burn. Oxy Vinyls shared its conclusions, but SPSI neither acted on them nor shared them with incident command, and Oxy Vinyls had no direct contact with incident command.

> **"If you're talking about a vent and burn decision, don't do it because of polymerization, because polymerization is not occurring."**
>
> – Oxy Vinyls VP of manufacturing, as told by Oxy Vinyls on-scene personnel

NS had requested that Oxy Vinyls communicate through SPSI. Oxy Vinyls personnel expected NS and its contractors to relay information to the rest of the incident command, but they did not; nobody conveyed Oxy Vinyls' opinion to the commander on the scene.

February 6: the meetings

Shortly after noon on February 6, the incident command met to decide whether venting and burning the VCM tank cars was the best option to mitigate the risk of an explosive tank rupture. The 60–100 attendees included people and organizations not part of the formal incident command, such as the governors of Ohio and Pennsylvania. Oxy Vinyls was not invited and did not attend.

According to the incident commander, no attendee objected to conducting the vent and burn based on the information presented and the potential BLEVE hazard as characterized by NS, SPSI, and SRS. (*See* What is polymerization?, *p. 8.*)

Yet, on-scene temperature trends did not indicate that a polymerization reaction was occurring, and postaccident examinations confirmed this. The NTSB later determined that the vent and burn procedure was not necessary to prevent a polymerization-induced explosion. The NTSB never found any evidence that polymerization was occurring.

13 minutes to decide, only one expert opinion

After this meeting, the incident commander focused on evacuating residents in preparation for a possible vent and burn. Once evacuations were completed, an NS representative asked the incident commander and the Ohio governor to meet in a separate room with NS, SPSI, and SRS personnel, including the chief executive officer of NS.

The incident commander reported that the SPSI president and SRS project manager said in this meeting that they wanted to begin the vent and burn before 3:00 p.m. to avoid the effects of atmospheric temperature inversion and allow the vapor cloud to disperse. They gave the incident commander 13 minutes to decide whether to allow them to proceed with the vent and burn.

Although the incident commander gave his approval, delays prevented contractors from carrying out the vent and burn until 4:47 p.m.

Contractors detonate explosives, releasing and burning VCM

Contractors breached the five tank cars at 4:47 p.m. Contractors positioned flares near each tank car to ignite vapor as it was expelled. Burning VCM resulted in a column of black smoke that grew into a persistent cloud. According to the NS system manager for hazardous materials, the cloud likely contained soot particles, carbon dioxide, carbon monoxide, hydrogen chloride, and a trace of phosgene (a toxic gas).

Alternatives to vent and burn

Without the vent and burn procedure, how else could VCM be removed?

- **Product transfer**—using the unloading valves and fittings to move the VCM into a receiving tank
- **Flaring**—gradually burning off flammable material at a safe location using a flare pipe attached to top fittings
- **A hot tap**—welding a threaded nozzle onto the tank and drilling through the tank wall to allow flaring or transfer even if the original unloading valves and fittings were damaged

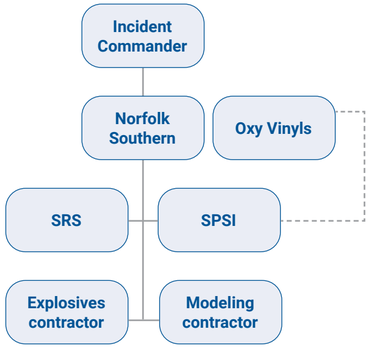
NS and SPSI first ruled out product transfer from any cars because three cars had damaged fittings (*see* photo *below*). They considered hot tapping and flaring until the energetic PRD release on February 4—which they attributed to polymerization.

A final alternative did not involve immediate removal of VCM from the scene: Do nothing, at least initially, because there was no evidence of polymerization, temperatures were trending down, and four out of five cars had been at the room temperature of a chilly room for hours.

Why is vent and burn a last resort?

VCM, a carcinogen, has been linked to liver, brain, and lung cancer. The products of vinyl chloride combustion, including hydrogen chloride, carbon monoxide, soot, and traces of phosgene, can be toxic to the community and the environment. Because of the risks associated with using a vent and burn procedure to unload certain hazardous materials, like VCM, from damaged tank cars, the FRA considers it a method of last resort.

Oxy Vinyls in the vent and burn decision



NS and several contractors worked together on scene throughout the response to the East Palestine derailment, spills, fires, and the vent and burn. The ultimate decision authority on scene was the incident commander, who relied on NS for information about its derailed train, including the VCM cars.

Oxy Vinyls was not an NS contractor but the VCM shipper and manufacturer. Oxy Vinyls disagreed with NS and its contractors that polymerization was happening, and relied on SPSI and NS to convey this dissenting opinion.

The dissenting opinion did not reach the incident commander.

Investigative hearing

The NTSB held an investigative hearing open to the public in East Palestine, Ohio, on June 22–23, 2023. During the hearing, the NTSB gathered sworn testimony about the Feb. 3 derailment. It was a fact-finding step in our safety investigation, and the testimony became part of the public record of the investigation.
The hearing focused on:
• hazard communications and emergency responder preparedness for the initial emergency response;
• circumstances that led to the decision to vent and burn the vinyl chloride tank cars;
• freight car bearing failure modes and wayside detection systems;
• tank car derailment damage, crashworthiness, and hazardous materials package information.

Safety issues

The NTSB investigated many issues to find out what happened, why it happened, and what needs to be done to prevent it from happening again.

Bearing failure

The derailment began when a bearing overheated. Although overheated bearings are the most common mechanical rail accident cause, there is no centralized database of information on failed bearings, such as why a bearing failed, when it failed, or what type of bearing was in what type of service. Because bearing burn-offs destroy evidence, there is a need to study many instances over time to determine factors predictive of failures. Without a database of information on failed bearings, there's no good way to assess risk or develop mitigation strategies for such a situation.

Problems with wayside detectors

In this derailment, although the bearing was on fire, the Salem HBD sent a noncritical alert that did not reach the crew. An alarm only sounded nearly 39 minutes later, and more than 20 miles away, in East Palestine. Because of design constraints, HBDs are likely to indicate misleadingly low bearing temperatures. In addition, the distance between HBDs varies, as do companies' standard operating procedures related to crew alert and alarm responses. Wayside detectors, like HBDs, vary in configuration, maintenance, and alarm criteria, and minimum universal standards don't exist. This makes it impossible to standardize crew responses to hot bearing alarms and can make it so a train crew doesn't have enough time to respond.

Emergency response

Ohio's volunteer firefighters receive no hazardous materials training, and get less than a quarter of the training time required in the NFPA standard for professional firefighter training. Further, the emergency response lacked efficient coordination because the responding agencies did not have common radio channels. Railcar placards became illegible after fire exposure, which also hampered response efforts. NS's delay in transmitting train consist information to emergency responders also increased responders' and the public's exposure to postderailment hazards.

Tank car performance

The postderailment fires likely began because of hazardous materials released from a punctured DOT-111 tank car. The intentional release of VCM from mechanically intact DOT-105 tank cars would likely never have been ordered if combustible and flammable liquids were not carried in, and subsequently released from, failure-prone DOT-111 tank cars. The presence of hazardous materials DOT-111 tank cars in a train can increase the risk of more resilient tank cars releasing hazardous materials following a derailment.

Vent and burn decision

The Chlorine Institute's Pamphlet 171 overstates the probability of VCM polymerization where tank cars remain intact. NS and its contractors who consulted Pamphlet 171 on scene overestimated the likelihood of polymerization. Additionally, NS and its contractors continued to describe polymerization as an imminent threat when expert opinions and available evidence should have led them to reconsider their course of action—on-scene temperature trends did not indicate that a polymerization reaction was occurring, which was confirmed by postaccident examinations. NS compromised the integrity of the decision to vent and burn the tank cars by not communicating expertise and dissenting opinions to the incident commander making the final decision.

Need for inward- and outward-facing recorders

Inward- and outward-facing recorders can allow railroads to verify train crew actions and help investigators improve the quality of investigations. The accident train was not required to have these recorders, and any important safety data they would have provided is lost.

Recommendations

We issued 34 new recommendations as a result of this investigation. We also reiterated one previously issued recommendation and classified four existing recommendations. To read the full findings and recommendations, see the report (RIR-24-05) at www.ntsb.gov.

- Research and establish regulations and best practices on defect detection systems. Use this information to:
  - develop thresholds for alerts and alarms;
  - establish appropriate distances between detectors;
  - determine standards for detector installation, inspection, and maintenance; and
  - inform railroads' operational responses to alerts and alarms.
- Build a database of bearing failure and replacement data.
- Improve firefighter training to meet a widely accepted standard and remove barriers to training.
- Immediately provide train consist information to emergency responders and incorporate lessons learned from this accident into emergency preparedness plans.
- Make hazardous materials placards able to survive accidents and fire.
- Expand the definition of high-hazard flammable train to include more hazardous materials and to account for differing tank car survivability. Amend the definition of key train.
- Require manufacturers to demonstrate their products work with intended lading.
- Review and revise hazardous materials emergency guidance.
- Require inward- and outward-facing audio and video recorders on locomotives.
- Get legislative authority to accelerate the removal of DOT-111 tank cars from flammable liquids service, and make a schedule to replace all nonpressurized tank cars in hazardous materials service that don't meet or exceed the DOT-117 specification.

Recipients

Secretary of Transportation

Federal Railroad Administration

Pipeline and Hazardous Materials Administration

State of Ohio

Columbiana County Emergency Management Agency

Association of American Railroads

National Volunteer Fire Council

International Association of Fire Chiefs

International Association of Fire Fighters

The Chlorine Institute

American Chemistry Council

Norfolk Southern Railway

Oxy Vinyls, LP

Parties to the investigation

- Federal Railroad Administration
- Pipeline and Hazardous Materials Safety Administration
- Ohio State Highway Patrol
- Village of East Palestine
- Norfolk Southern Corporation
- Trinity Industries Leasing Company
- International Association of Sheet Metal, Air, Rail and Transportation Workers
- International Association of Fire Fighters
- Oxy Vinyls, LP
- GATX Corporation
- Midland Manufacturing
- Brotherhood of Locomotive Engineers and Trainmen
- Transportation Communications Union–Brotherhood of Railroad Carmen

The National Transportation Safety Board 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, hazardous materials, and commercial space. We determine the probable causes of the accidents and events that we investigate, and issue safety recommendations aimed at preventing future occurrences.