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Railroad Investigation Report RIR-26-07

Canadian Pacific Kansas City Railroad Derailment with Subsequent Hazardous Materials Release and Fire

Bordulac, North Dakota
July 5, 2024

Abstract: On July 5, 2024, about 3:36 a.m. local time, eastbound Canadian Pacific Kansas City Railroad (CPKC) freight train 242-03 derailed near Bordulac, North Dakota. The train derailed 29 railcars, which included 17 tank cars transporting hazardous materials. A postaccident release of methanol from multiple derailed tank cars and a subsequent pool fire led to a release of anhydrous ammonia from other tank cars. There were no reported injuries, but a residence near the accident area was evacuated. Safety issues identified in this investigation include the following:

- CPKC's culvert inspection practices that are insufficient to identify culvert separation or a track bed vulnerable to collapse;
- Tank car standards for pressure relief devices and performance requirements for thermal protection systems that do not ensure the survivability of tank cars carrying poison inhalation hazard materials;
- Vulnerability to thermal damage of manway gaskets on tank cars used in flammable liquid service;
- Standards and practices that allow tank cars in poison inhalation hazard service to be positioned next to tank cars carrying flammable liquids; and
- Hazards of the continued use of US Department of Transportation-111 tank cars in flammable liquid service.

As part of this investigation, the National Transportation Safety Board issues new recommendations to the Pipeline and Hazardous Materials Safety Administration, the Association of American Railroads, the American Short Line and Regional Railroad Association, and CPKC. The Board reiterates and classifies recommendations to the Federal Railroad Administration and to the Pipeline and Hazardous Materials Safety Administration.

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Acronyms and Abbreviations

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AFFTAC	Analysis of Fire Effects on Tank Cars
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARI	American Railcar Industries
ASLRRA	American Short Line and Regional Railroad Association
ATI	automated track inspection
CFD	Carrington Fire Department
CP Home Safe	<i>CP Home Safe, United States Hazardous Materials Instructions for Rail, Version 1 (CPKC)</i>
CPKC	Canadian Pacific Kansas City Railroad
EPDM	ethylene propylene diene monomer
hazmat	hazardous materials
HMIR	<i>United States Hazardous Materials Instructions for Rail (AAR)</i>
HMR	Hazardous Materials Regulations
IC	incident commander
MP	milepost
NTSB	National Transportation Safety Board
PIH	poison inhalation hazard
PRD	pressure relief device
SCFM	standard cubic feet per minute

Executive Summary

What Happened

On July 5, 2024, about 3:36 a.m. local time, Canadian Pacific Kansas City Railroad (CPKC) freight train 242-03 derailed 29 railcars, including 17 hazmat tank cars, near Bordulac, North Dakota, as it traveled east on the Carrington Subdivision. Methanol (a flammable hazardous material) was released from some of the derailed tank cars and led to a pool fire.¹ The heat from the pool fire resulted in the release of anhydrous ammonia from other derailed cars. In all, nine hazardous material tank cars were breached (punctured or torn) during or after the derailment and released lading (content of the tank cars). No injuries were reported, but a residence near the accident area was evacuated.

What We Found

We found that as train 242-03 traversed a subgrade void, caused by a degraded concrete drainage culvert underneath the track, the track suddenly collapsed, causing a dip in the rails and a broken south rail. The 48th through 76th railcars on train 242-03 derailed when they traversed the broken rail with no track bed support. In the derailment, five methanol tank cars were breached, supplying fuel for a pool fire that led to thermal breaching of three of the derailed anhydrous ammonia tank cars.

We found that although CPKC's culvert inspection frequency was sufficient, their inspection methods did not help inspectors evaluate all potentially hazardous conditions. The inspection program also lacked guidance for inspectors to appropriately rate the risk posed by these conditions. Because of this, ratings from multiple inspections before the accident did not reflect the poor conditions of the culverts at the accident location or prompt their remediation.

The investigation found that the tank shells of two of the three DOT-112 anhydrous ammonia tank cars that developed thermal tears did so because the rate at which their pressure relief devices (PRDs) vented material was insufficient to offset the internal pressure rise caused by increased temperatures from the pool fire. A greater PRD flow capacity would have improved the ability of these tank cars to survive the pool fire without incurring thermal breaching damage. Postaccident testing indicated that the start-to-discharge pressures of the PRDs on the two

¹ The term *pool fire* appears in federal regulations but is not precisely defined. Generally, a pool fire is a diffused fire fed by released material and is capable of engulfing a tank car.

thermally torn anhydrous ammonia tank cars were elevated above those for which they were designed, but we found the start-to-discharge pressures were likely not as large a factor in the formation of thermal tears in the tank shells as the insufficient flow capacity of the PRDs. We found that adjusting PRD parameters to balance the physical characteristics of the lading and the need to vent toxic material can limit the potential for thermal tears. Further, we identified that the human and environmental damage of a catastrophic release of poison inhalation hazard (PIH) materials is such that PIH tank cars should allow for no release of these materials other than through reclosing PRDs. We found that federal thermal protection system performance criteria, which allow eventual tank failure after 100 minutes in a pool fire scenario, do not adequately consider the different physical characteristics and toxicological effects of releases of PIH materials into a community.²

This accident was one of the first major derailments involving a hazmat release the National Transportation Safety Board has investigated since the 2023 Norfolk Southern Railway derailment in East Palestine, Ohio. As in East Palestine, DOT-111 tank cars released hazardous materials in the Bordulac derailment. The investigation found that the continued use of DOT-117R tank cars, which are retrofitted DOT-111 tank cars, in flammable liquids service has not resulted in the same safety improvements as newly built DOT-117 tank cars. We found that industry-recommended practices and federal requirements for the placement of cars within a train consist do not sufficiently protect against harmful interactions that can occur between adjacent tank cars carrying PIH materials and flammable liquids in a derailment scenario.³ We also found that, as in previous accidents, the vulnerability of DOT-111 tank cars to mechanical damage contributed to the thermal damage and release of PIH materials from other, more-robust tank cars. In addition, the gasket material used to seal the manway of DOT-117R tank cars is vulnerable to thermal damage, which elevates the risk of a hazardous materials release through this unintended pathway.

We determined that the probable cause of the derailment of Canadian Pacific Kansas City Railroad train 242-03 was the collapse of the subgrade supporting the track structure. Contributing to the collapse was an erosion-caused void in the railroad subgrade created by a separation of culvert segments at the accident location, which went undetected because of CPKC's insufficient culvert inspection requirements. Contributing to the severity of the accident was the release of highly

² A *thermal protection system* is a system of insulating and pressure-relieving components that work together to increase the thermal resistance of a tank car.

³ The term *train consist* generally refers to the contents of a train, including the position of locomotives and cars, as well as both nonhazardous and hazardous freight within those cars.

flammable hazardous materials caused by the breaching of five methanol tank cars, which supplied fuel for a pool fire that then led to thermal breaching of three anhydrous ammonia tank cars. Contributing to the severity of the release was inadequate thermal performance of the derailed anhydrous ammonia tank cars and the proximity of tank cars transporting highly flammable hazardous materials to tank cars carrying poison inhalation hazard materials in the train consist. Also contributing to the severity of the release was the continued use of DOT-111 and DOT-117R tank cars, which sustained considerable mechanical damage, and the use of manway gaskets that were vulnerable to thermal damage.

What We Recommended

As a result of this investigation, the NTSB issued 11 new recommendations and reiterated six recommendations. We recommended that Canadian Pacific Kansas City Railroad revise its culvert inspection procedures to require internal inspections, either in person or assisted by technology, and that the railroad provide detailed guidance to culvert inspectors on proper ratings for degraded culverts and require remedial actions to fix such culverts.

We recommended that the Pipeline and Hazardous Materials Safety Administration (PHMSA) issue guidance for the selection of an optimal PRD based on the characteristics of the PIH material transported in a tank car and develop and implement new thermal performance criteria for tank cars carrying PIH materials that prevent the release of the tank car's lading during a fully engulfing pool fire except through reclosing PRDs. We also recommended that PHMSA, working with the Association of American Railroads (AAR), identify the appropriate amount of separation within a train between tank cars transporting PIH materials and those transporting flammable hazardous materials. We then recommended that, once appropriate separation criteria have been identified, that PHMSA again work with the AAR to require physical separation between PIH tank cars and tank cars carrying flammable hazardous materials.

We recommended that the AAR revise both the formula for required PRD flow capacity contained in its *Specifications for Tank Cars* and PRD and thermal protection system requirements to ensure tank cars carrying PIH materials can survive engulfing pool fire conditions. We also recommended that the AAR and the American Short Line and Regional Railroad Association inform their members of the circumstances of the accident and encourage them to (1) review and revise as necessary their culvert inspection procedures to require internal inspections either on foot or by using technology and (2) provide detailed culvert rating guidance and require remedial actions to be taken within set timeframes when necessary.

Finally, we reiterated and classified four recommendations to PHMSA, two regarding the performance of gaskets used in certain tank cars (R-23-14 and R-23-15) and two related to improved safety standards of non-pressure tank cars in hazardous material service (R-24-12 and R-24-13). We reiterated and classified two recommendations to the Federal Railroad Administration related to the performance of gaskets used in certain tank cars (R-23-12 and R-23-13).

1 Factual Information

1.1 The Accident

On July 5, 2024, about 3:36 a.m. local time, eastbound Canadian Pacific Kansas City Railroad (CPKC) freight train 242-03 derailed 29 railcars at milepost (MP) 343.4 on the main track of the Carrington Subdivision near Bordulac, North Dakota.¹ Train 242-03 was a designated key train that contained 84 railcars carrying hazardous materials (hazmat) and was traveling about 45 mph when it derailed.² CPKC records indicate that of the 29 derailed railcars, 17 were tank cars, and 9 of these were breached (punctured or torn) during the derailment or in the postaccident fire. All 9 of the breached tank cars released lading.³

Methanol—a flammable hazardous material—released from five of the breached tank cars and collected in a pool with standing water, resulting in a pool fire surrounding the derailed railcars.⁴ (See figure 1.) Anhydrous ammonia released from the other four breached railcars. There were no reported injuries from the accident, although first responders initiated a voluntary evacuation for 2 days of a nearby home. CPKC estimated damages to be about \$3.6 million. At the time of the accident, visibility conditions were dark and clear; the weather was 59°F with no precipitation. The track and the surrounding area were wet from rainfall; about 2 inches of rain had fallen the previous day, concluding by about 9:00 p.m. on July 4, 2024.

¹ Visit [ntsb.gov](https://www.ntsb.gov) to find additional information in the [public docket](#) for this NTSB accident investigation (case number [RRD24LR012](#)). Use the [CAROL Query](#) to search safety recommendations and investigations.

² (a) A *key train* is defined in the Association of American Railroads (AAR) *United States Hazardous Materials Instructions for Rail* (HMIR) as a train with any one of the following components: at least one tank car containing anhydrous ammonia, ammonia solutions, or material designated as a poison or toxic inhalation hazard; 20 railcar loads of any combination of hazardous material; or one or more railcar loads of spent nuclear fuel or radioactive waste. As a key train, the maximum speed of train 242-03 was 50 mph. (b) Train 242-03 contained 21 tank cars of anhydrous ammonia, 9 tank cars of methanol, 53 hazmat tank cars, and one hazmat non-tank car.

³ *Lading* refers to the contents, or load, of a railcar or other vessel.

⁴ (a) A train derailment provides numerous potential ignition sources, such as sparks from metal-on-metal collision. (b) The term *pool fire* appears in federal regulations but is not precisely defined. Generally, a pool fire is a diffused fire fed by released material and is capable of engulfing a tank car.



Figure 1. Aerial view of the derailment site. (Source: Foster County Emergency Management.)

The CPKC Carrington Subdivision extends from MP 253.6 near Enderlin, North Dakota, to MP 395.7 near Harvey, North Dakota. CPKC train 242-03 was a mixed-manifest train that was composed of 1 head-end locomotive CP8882, 1 rear distributed-power locomotive KCSM4535, 126 loaded railcars, and 25 empty railcars.⁵ The train operated across multiple crew districts in the 1,347 miles between its origination point in Lambton Park Yard, Alberta, Canada, and its intended destination of St. Paul, Minnesota.⁶ (See figure 2.) At the time of the accident, the train crew consisted of one engineer and one conductor, working from the operating compartment of the lead locomotive. They went on duty in Minot, North Dakota, at 9:15 p.m. on July 4, 2024.

⁵ *Distributed power locomotives* are used to manage in-train forces and improve the handling of long or heavy trains.

⁶ A *crew district* is the portion of a trip operated by a train crew between two set points: the home terminal and the away-from-home terminal. Train crews change out at the set points; in the case of this accident, the crew was operating the train from Minot to Enderlin.

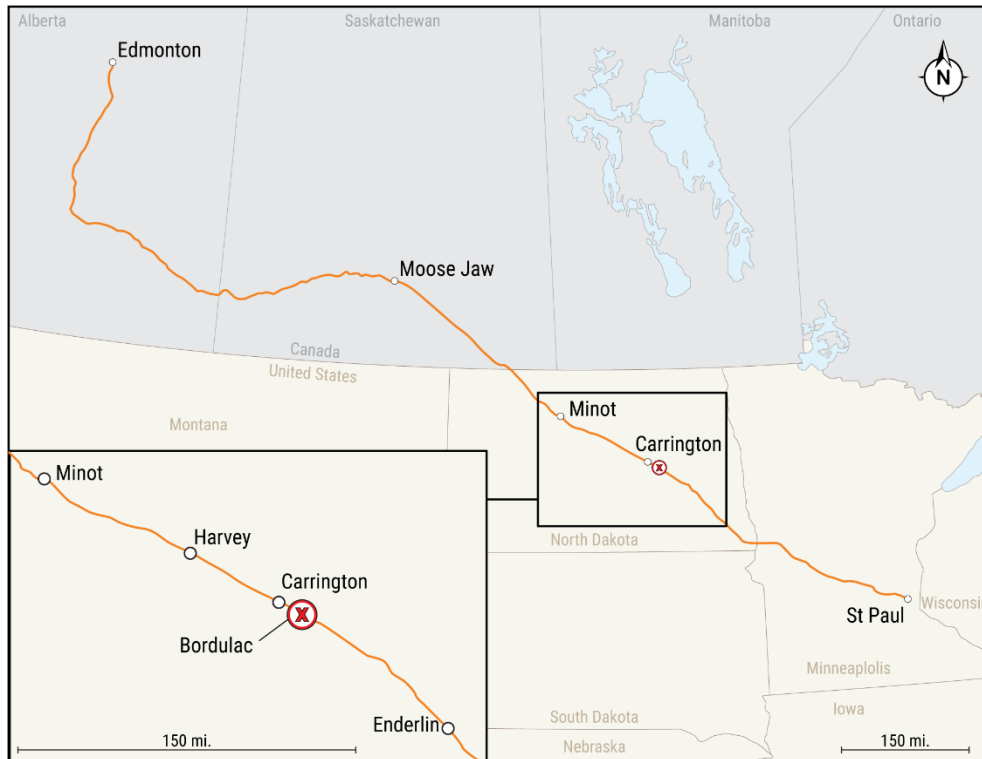


Figure 2. CPKC network from Edmonton, Alberta, Canada, to St. Paul, Minnesota.

Train 242-03 departed Minot about 10:30 p.m. on July 4, with the crew scheduled to take the train to Enderlin, North Dakota. Qualified mechanical inspectors performed an initial terminal inspection at Lambton Park Yard on July 2, 2024, and a second inspection in Moose Jaw, also in Alberta, on July 4, 2024.⁷

En route, the crew added 29 railcars to the head end of the train at the railyard in Harvey, where they received paperwork containing information about the new railcars and their contents and then proceeded toward Enderlin.⁸ Event recorder data showed the throttle position was decreased to idle on both the lead and distributed-power locomotives and that the train's speed was about 44 mph around MP 343.5 after the train left the railroad station at Bordulac. In interviews with the National Transportation Safety Board (NTSB), the crew recalled observing trainline-initiated alarms caused by an emergency braking application. A review of train 242-03's event recorder data showed that at 3:36:51 a.m., the train experienced a train-line-initiated emergency braking application, and at 3:36:58 a.m., the engineer applied the

⁷ Federal regulations at Title 49 *Code of Federal Regulations (CFR)* 232.205 require the railcars in a train to receive a Class 1 air brake test at certain points in the train's journey; the first of these, the *initial terminal inspection*, is conducted where the train is originally assembled.

⁸ Operating employees inspected the railcars picked up at Harvey and noted no exceptions.

dynamic brakes.⁹ After the brake application, the train traveled about 1,730 feet before it stopped.

The conductor told NTSB investigators he reported an emergency on the radio and then saw, in the locomotive's side-view mirror, a "very large fireball." The conductor reported the fire to the CPKC dispatcher and recalled watching the flames as he spoke to the dispatcher. After the CPKC operations center gave the crew permission to separate the lead locomotive (CP8882) from the rest of the train, the conductor dismounted the locomotive. The conductor then disconnected the lead locomotive, and the crew moved the locomotive eastward to a highway-railroad grade crossing further away from the fire.

1.1.1 Derailment

The derailed equipment, all loaded railcars, included 12 covered hopper cars of polypropylene (plastic) pellets, 6 tank cars of methanol, and 11 tank cars of anhydrous ammonia. (See figure 3.) Methanol tank car (48) PROX045220 was the first to derail and came to rest south of the track. Anhydrous ammonia tank cars line 49-59 came to rest in an alternating left-right chevron style.¹⁰ Five methanol tank cars (line 60-64) ran into the derailed anhydrous ammonia tank cars from behind and derailed in an accordion fashion. The final 12 railcars to derail (line 65-76) were the hopper cars carrying plastic pellets; two of these railcars overrode the methanol and anhydrous ammonia tank cars and came to rest on top of them. CPKC estimated that about 122,000 gallons of methanol and 140,000 gallons of anhydrous ammonia were released from the derailed tank cars.¹¹ (See table 1.)

⁹ (a) An *emergency braking application* uses the maximum braking force available to stop a train as quickly as possible. The air brakes of most trains, including train 242-03, are activated by reducing the pressure in the brake pipe or *train line* that runs the length of the consist. If the air hoses joining railcars together become disconnected, the pressure in the train line falls, automatically applying the emergency brakes. (b) *Dynamic braking* uses locomotives' traction motors to slow a train.

¹⁰ The *line number* indicates the position of a piece of equipment in a train consist; higher numbers are nearer the rear of the consist. In this report, the line numbers of accident tank cars are enclosed in parentheses when they accompany the car's identification number.

¹¹ On July 25, 2024, CPKC filed a hazardous materials incident report with PHMSA estimating total release amounts. These amounts include releases that were due to mechanical and thermal tank breaching damages, normal PRD actuation, postaccident controlled release flaring operations, and purging and cleaning of tank car residues.

Table 1. Derailed tank car lading and release estimates.

Line number	Car number	US Department of Transportation tank car specification	Commodity	Reported amount released (gal.)
48	PROX45220	117R100W	Methanol (UN1230)	0
49	UTLX971162	112H500W	Anhydrous ammonia (UN1005)	1,861
50	TILX500864	112J500I	Anhydrous ammonia	1,025
51	TILX500752	112J500I	Anhydrous ammonia	731
52	TILX500890	112J500I	Anhydrous ammonia	693
53	SHQX10732	112J500I	Anhydrous ammonia	6,472
54	TILX500730	112J500I	Anhydrous ammonia	30,213
55	TILX501050	112J500I	Anhydrous ammonia	30,232
56	UTLX971273	112J500I	Anhydrous ammonia	29,246
57	TILX501231	112J500I	Anhydrous ammonia	1,857
58	SHQX10754	112J500I	Anhydrous ammonia	7,784
59	SHQX10805	112J500I	Anhydrous ammonia	30,291
60	CTCX300362	117R100W	Methanol (UN1230)	13,558
61	TILX355610	117J100W	Methanol	26,036
62	MFCX132265	111S100W1	Methanol	26,526
63	CTCX300358	117R100W	Methanol	27,849
64	CTCX732746	117R100W	Methanol	27,744

Note: Breached tank cars are in boldface text.

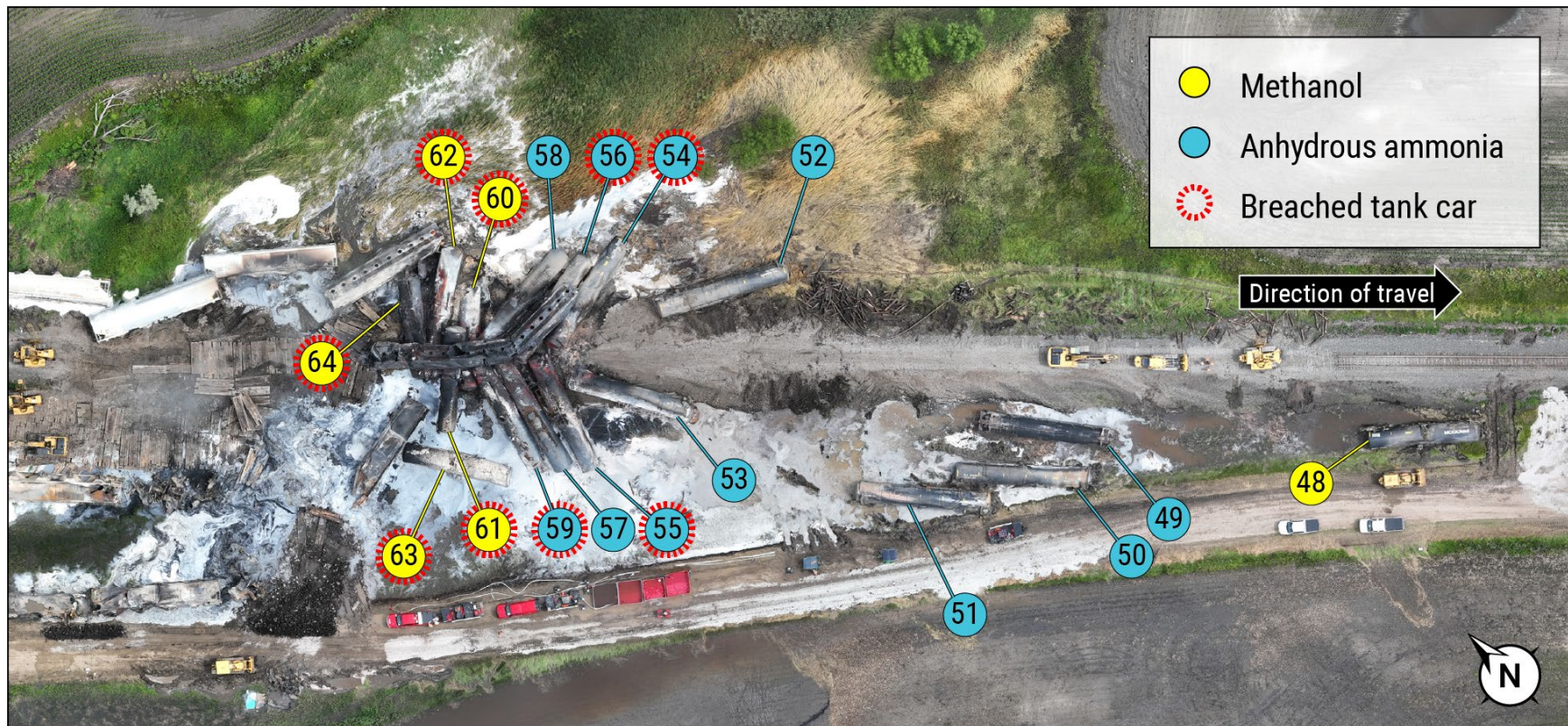


Figure 3. Postderailment positions of derailed railcars in train 242-03. Some of the cars had been moved during emergency response activities. (Source photo: Pinnacle Engineering.)

1.1.2 Emergency Response

Records from the Carrington Fire Department (CFD) show that State Radio initially notified the CFD fire chief of a train fire about 3:43 a.m. on July 5, 2024.¹⁵ Records indicate the fire chief, who served as the incident commander (IC), contacted State Radio about 3:48 a.m. and learned the train contained hazardous materials (including anhydrous ammonia, methanol, and sulfur) and plastics. About 4 a.m., the CPKC superintendent of operations for North Dakota notified the CPKC regional hazmat director of the derailment, who organized CPKC's emergency response and remained on scene throughout the duration of the incident and cleanup. He estimated that in total, more than 100 CPKC personnel responded to the accident.

About 25 of the 32 volunteers from CFD participated in the emergency response to the accident, and received mutual aid from fire departments in Jamestown, Pingree, Kensal, New Rockford, Harvey, Sykeston, and Rugby. A unified command was established consisting of CPKC, CFD, the Foster County Commissioner, and Foster County Emergency Management.

Local CPKC representatives began arriving on scene soon after the fire department personnel. In an interview, the IC told NTSB investigators that he did not immediately obtain a train consist from CPKC but that he knew from his conversation with State Radio that the consist contained flammable materials.¹⁶ Around 4:15 a.m., the IC told the NTSB that he heard pressure relief devices (PRDs) on derailed tank cars releasing material and saw methanol burning on water that was pooled around the derailed cars, along with black smoke from burning plastics.¹⁷ (See figure 4.)

¹⁵ State Radio is North Dakota's statewide emergency communications center.

¹⁶ CPKC sent the IC a train consist about 7:10 a.m. He recalled first reviewing it between 9 and 10 a.m.

¹⁷ (a) A *pressure relief device* is a fitting on a tank car that opens at a predetermined setting to reduce the pressure within a tank car tank that results from exposure to abnormal conditions. (b) A methanol-based fire burns nearly invisibly but can be seen in certain low light conditions or with a thermal camera.



Figure 4. Derailement scene and pool fire around 4:58 a.m. (Photo courtesy CFD.)

Throughout the emergency response, the IC kept in contact with the Jamestown regional hazmat team but did not request their assistance.¹⁸ The IC told the NTSB that he did not need to request assistance from the hazmat team because he knew CPKC was sending hazmat experts, that he was trained in responding to hazardous materials incidents, and because he had handled previous hazmat derailments while part of CFD. The IC described his response in the first several hours after the derailment as “strictly defensive” to protect nearby populations from hazmat exposure. About 4:33 a.m., the IC asked the Foster County Sheriff to notify any

¹⁸ The North Dakota Department of Emergency Services works with certain fire departments to handle hazmat and structural collapse emergency response in four statewide regions. The Jamestown Fire Department leads the hazmat response team for the Southeast region,

residents of the farm located to the southeast and of a home located to the southwest of the accident site to evacuate.¹⁹

About 5:05 a.m., emergency response personnel wearing self-contained breathing apparatuses walked the length of the derailment to obtain a count of the derailed railcars and general characteristics of the hazmat release. They estimated between 15 and 30 railcars were involved, and the IC recorded any visible railcar numbers. CFD records indicate firefighters noticed an anhydrous ammonia odor to the south side of the tracks about 6:05 a.m. Emergency personnel continued to monitor PRD releases from derailed tank cars, and North Dakota State Highway Patrol barricaded access to the site.

The train crew remained on locomotive CP8882 until about 6:37 a.m., when the CPKC superintendent directed them to reattach the locomotive to the railcars east of the derailment and pull them east toward Dry Lake to clear the area. About an hour later, the CPKC superintendent directed the crew to move the railcars still on the tracks west of the derailment away from the fire, using the locomotive on the rear of the train. The conductor of train 242-03 detached hopper car line 77, the first railcar to the west of the pileup that had not derailed, from the derailed cars. The engineer, who had boarded locomotive KCSM4535 at the far west end of the train consist, then pulled the railcars away from the fire. The train crew subsequently left the site to undergo FRA postaccident toxicological testing.

As initial fire suppression actions began to reduce the amount of smoke emanating from burning plastics and other materials, drone video from about 9:11 a.m. on July 5 showed a bright white vapor cloud indicating the presence of an active anhydrous ammonia vapor release. (See figure 5.) The video showed the dense white cloud spread in a "V" pattern, remaining relatively low to the ground and appearing to dissipate over puddled water and nearby wet agricultural fields.²⁰ Emergency responders used water spray to control the ammonia vapor. CPKC produced a plume model for the pool fire soot dispersion about 9:48 a.m. The model indicated a plume height of about 100 feet for more than one-half mile in length, oriented toward the southeast.

By the evening of July 5, the plastic pellet fire was largely under control, and the methanol fire was diminishing, but anhydrous ammonia vapor was still present. Using heavy equipment, responders moved some of the derailed tank cars from both

¹⁹ The evacuation covered 1 square mile and involved one individual.

²⁰ Anhydrous ammonia is hydrophilic, meaning it is attracted to water.

ends of the pileup to help identify which of the derailed tank cars were actively releasing hazardous materials or were breached. Subsequently, emergency responders identified a shell breach on anhydrous ammonia tank car (59) SHQX10805.



Figure 5. Anhydrous ammonia releases. (Photo courtesy Foster County Emergency Management.)

NTSB investigators reviewed video taken after the accident, in which liquid methanol can be seen flowing from punctures in both ends of tank car (62) MFCX132265 for more than 10 hours. Over the course of the day on July 6, CPKC identified shell breaches on three other tank cars carrying anhydrous ammonia: (54) TILX500730, (55) TILX501050, and (56) UTLX971273. As cleanup proceeded, CPKC and its contractors found four other methanol tank cars with breaching damage.²¹ The damages to the tank cars are detailed further in section 1.4.

²¹ A *breach* is any failure of a tank car vessel that results in a release of its lading.

1.1.3 Cleanup

For about three weeks following the derailment, CPKC crews addressed releases from breached anhydrous ammonia tank cars using a variety of standard control methods. In one case, a magnetic patch was placed over a shell tear where it was exposed beneath a torn jacket. CPKC controlled releases from two other tears using tarps to trap and condense anhydrous ammonia vapor, which prevented persistent downwind plume formation. Residual contents of anhydrous ammonia in the breached tank cars were conveyed to vapor flare devices, a process that took 1–2 weeks for each tank car.²² CPKC removed the remaining liquids and residues in the six derailed methanol tank cars using a combination of traditional transloading, purging, and steam-cleaning techniques.

CPKC constructed a containment berm with diversion pumps to block surface water discharges into Lake George, about one-quarter mile northeast and downstream of the derailment site, and used frac tanks to contain the methanol- and ammonia-contaminated water.²³ Beginning on July 6, crews collected and aerated about 1.6 million gallons of contaminated water, which allowed it to be applied to nearby agricultural fields as fertilizer.

1.2 Railroad Infrastructure

1.2.1 Track and Culverts

The track at the accident location was FRA Class 4 single main track with a maximum authorized speed of 60 mph for freight trains.²⁴ The track was typical hardwood crosstie construction with crossties measuring 9 inches by 7 inches by 8 feet, 6 inches and spaced 19.5 inches on center. The rail was continuously welded 115-lb rail fastened to the crossties using standard double-shoulder 13-inch tie plates with four 6-inch track spikes per plate.²⁵ The track was supported by granite rock ballast.

²² A *vapor flare* system uses combustion and an open-air flame to burn waste gases.

²³ A *frac tank* is a large portable container used for temporary storage and separation of liquids such as oil/water mixtures.

²⁴ FRA regulations in 49 *CFR* 213.9 categorize track classes based on their speed limits.

²⁵ The rail brand was 1150-8 VT CF&I 1997.

CPKC inspection records noted no defects on the main track between MPs 338.4 and 347.4 for the 60 days preceding the accident at MP 343.4.²⁶ The records noted a condition of one broken bolt at an insulated joint identified at MP 342.80 on May 11, 2024, that was repaired on May 17 by replacing the insulated joint.²⁷ In the two-week period preceding the accident, CPKC conducted the four FRA-required regular inspections (June 24, 27, and 29 and July 2) and two additional track inspections (June 25 and July 3). These inspections noted no conditions or defects.

Two drainage culverts ran perpendicular beneath the track at the derailment site at MP 343.4. Installed in October 1913, the two culverts were each 48 feet long and consisted of five sections of 48-inch-diameter concrete pipe, connected at bell-and-spigot joints.²⁸ This report refers to them as the west culvert and east culvert, as indicated in figure 6.



Figure 6. Aerial image of derailment location. (Source: Google Earth).

About 20 hours before the accident, on July 4 about 8:16 a.m., a CPKC-owned automated track inspection (ATI) vehicle traversed the accident location. The ATI

²⁶ A track *defect* indicates noncompliance with FRA regulations.

²⁷ A track *condition* indicates noncompliance with CPKC standards but still within FRA limits.

²⁸ A *bell-and-spigot joint* connects two sections of pipe, with a narrower end (spigot) fitting into a flared end (bell).

vehicle measured track geometry parameters, including each rail's vertical profile.²⁹ In addition to the track geometry measuring equipment, the ATI was equipped with an outward-facing video camera. NTSB investigators reviewed the ATI records for the derailment area, and the records did not identify any FRA defects or other CPKC alerts. The ATI records indicated that the measurements at the accident location, shown in table 2, were within the limits specified by federal regulation.

Table 2. ATI measurements for derailment area, July 4, 2024 (the day before the accident).

Track Geometry Parameter	Measured Values
Gage (distance between the heads of rails)	56.5–57 inches
Crosslevel (relative elevation of a track's two rails)	< 0.32 inches
Alignment (horizontal/lateral deviation of rails) per 62-ft. section	< 0.28 inches
Profile (vertical height/depth of humps/dips) per 62-ft. section	< 1.18-inch dip (north rail)

Both locomotives on train 242-03 were equipped with image recording systems. NTSB investigators reviewed the video from these locomotives and video from the outward-facing cameras on the ATI vehicle and six other trains that traversed the area on July 4 or 5. The videos showed no indications of visible track or culvert defects or of developing unsafe conditions, either in the hours preceding the derailment or as the accident train approached the derailment location, shown in figure 7.

²⁹ In this report, *vertical profile* refers to deviations from the uniform profile of the track surface on either rail at the midpoint of a 62-foot section of track. Track surface limits are established in 49 CFR 213.63.



Figure 7. A still image from lead locomotive CP8882 as it approached the derailment area, with the outlets of the east and west culverts visible. (Source: CPKC).

CPKC records indicated that about a year before the accident, on May 17, 2023, a train crew reported rough track at MP 343.4, and a track inspector was immediately dispatched to inspect the area. The inspector found a crosslevel defect: the south rail measured 3 inches higher than the north rail, which was greater than the maximum of 1.25 inches allowed by federal regulation for the class of track.

To repair the crosslevel defect, CPKC crews added additional ballast (rock) at the site and attempted to raise and level the track with a tamper. In interviews with the NTSB, crew members recalled that as they began tamping the ballast, a section of the track bed surface suddenly dropped vertically where they were tamping. The low section extended beneath five crossties and was the width of the track. (See figure 8.)



Figure 8. Low section of track bed at MP 343.4 on May 17, 2023. (Source: CPKC.)

The crew members alerted the CPKC bridge maintenance manager, who oversaw maintenance of bridge structures along about 700 miles of track in Minnesota and North Dakota, including about 2,000 culverts. The bridge maintenance manager told the NTSB that he and his team observed the east culvert during the May 17 work and noted partial separation of two culvert segments. Photos taken at this time show extensive debris and ballast inside it, blocking water flow. (See figure 9.)

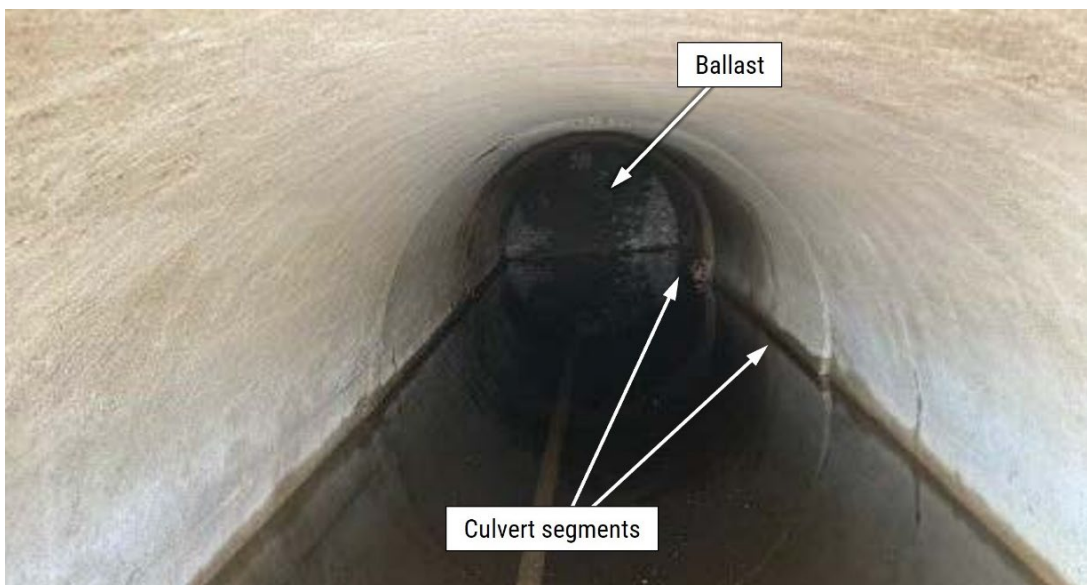


Figure 9. View looking north through the east culvert on May 17, 2023. (Source: CPKC.)

The CPKC bridge maintenance manager told the NTSB that to repair the track bed that fell away during the tamping operation, the crew removed all of the ballast and fill material above the culvert and placed bags of concrete mix on top of the gap created by the separated culvert segments. They then watered the bags to create a cement patch over this section of the culvert before restoring the subgrade and track bed. The bridge maintenance manager stated that at the time, the necessary equipment was not available to remove the ballast and sediment that partially blocked the east culvert, adding that heavy water flows often pushed blockages from culverts on their own. After these repairs, and until the accident, track inspection reports noted no further track surface issues.

1.2.2 Signal and Train Control

Train movements in the accident area were governed by the CPKC traffic control system and coordinated by a train dispatcher located at the CPKC dispatch center in Minneapolis, Minnesota. Train movements on the Carrington Subdivision, where the accident occurred, were governed by operating rules, special instructions, and timetable instructions. The subdivision's main tracks were also equipped with an overlaid positive train control system (Interoperable Electronic Train Management System).³⁰ The subdivision's signal system used coded track circuits for train occupancy detection and color-light wayside signals to convey speed and movement authority to train crews.

1.3 Train 242-03 Crew

Enderlin was the home terminal of both the engineer and conductor of train 242-03. The engineer was hired by CPKC in 2010. CPKC records indicated that he completed his most recent rules, subdivision knowledge, hazmat, and knowledge exams between January 15 and 17, 2024. He was last recertified as a locomotive engineer on February 15, 2024.

The train 242-03 conductor was hired in November 2022 and certified as a conductor in June 2023. His most recent exams were on the following dates: rules,

³⁰ *Positive train control systems* are overlaid on a railroad's existing signal infrastructure and use a communications system and locomotive-mounted, wayside, and back-office equipment to enforce signals and speed restrictions.

November 16, 2023; hazmat, January 4, 2023; and subdivision knowledge, January 21, 2023.³¹

The conductor and engineer were drug- and alcohol-tested after the accident according to FRA regulations at Title 49 *Code of Federal Regulations (CFR)* 219.203 (d)(1) and (d)(2) in Jamestown between 12:20 and 12:55 p.m. on July 5, 2024.³² Results were negative for all tested-for substances.

1.4 Postderailment Railcar Examinations

After the accident on July 5, NTSB investigators inspected the non-derailed equipment, and on July 6, documented damage to 12 railcars between lead locomotive CP8882 and the first derailed railcar (48) PROX045220, detailed in table 3. Figure 10 shows examples of the different damage types.

Table 3. Damages to non-derailed railcars.

Line number	Car number	Damage description
36	TILX500727	#1 axle contact with draft sill ¹
37	TILX500866	#1 axle contact with draft sill
38	TILX500886	#1 axle contact with draft sill
39	TILX500825	#1 axle contact with draft sill
40	SHQX10765	#4 axle contact with draft sill Rail impact marks on wheels R1, R3, and R4
41	SHQX10687	#4 axle contact with draft sill Rail impact marks on wheels R1, R2, R3, and R4

³¹ Engineers and conductors are each required to be recertified every 36 months, as established in 49 *CFR* 240.217 for engineers and in 49 *CFR* 242.201 for conductors.

³² (a) The FRA tested for amphetamine, methamphetamine, MDMA/MDA, cocaine, marijuana, morphine, hydrocodone, hydromorphone, oxycodone, oxymorphone, phencyclidine, and codeine. Additional testing was conducted for barbiturates, benzodiazepines, methadone, tramadol, and blood ethyl alcohol. (b) Title 49 *CFR* 219.203(d)(1) states that railroads should collect specimens for drug testing within 4 hours. If testing is not possible within this timeframe, the railroad must submit their reasoning to the FRA in writing. CPKC determined this accident required testing (as a hazmat release involving an evacuation) about 6 hours after it occurred. As required, CPKC shared its reasoning with FRA in writing.

Line number	Car number	Damage description
42	TILX500738	#1 axle contact with draft sill Rail impact marks on wheel L2
43	TILX500913	#4 axle contact with draft sill Rail impact marks on wheel R2
44	TILX500961	#1 axle contact with draft sill
45	PROX45410	#1 axle contact with draft sill Broken buffer castings on A and B ends ² Rail impact mark on wheel L3
46	PROX43474	#1 axle contact with draft sill Broken buffer castings on the A and B ends Rail impact mark on the wheel L2
47	CTCX300366	A-end knuckle broken A-end coupler key bent

Note: In this table, railcar axles are numbered 1–4 in the direction of the railcar’s A end (the end of the railcar without the hand brake) to its B end (the end to which the hand brake is mounted). Wheels are numbered L1–L4 (left side) and R1–R4 (right side) in the same direction.

¹ A *draft sill*, part of a railcar’s underframe, incorporates the draft gear that is designed to transfer longitudinal draft (tension) and buff (compression) forces throughout the length of a train.

² A *buffer casting* is located at the end of the draft sill. The railcar coupler contacts the buffer casting when the draft gear is fully compressed.



Figure 10. Damage to non-derailed equipment: (a) axle contact with draft sill, (39) TILX500825; (b) damaged buffer casting, (46) PROX43474; and (c) broken-rail witness mark on wheel, (41) SHQX10687.

On August 7-8, 2024, NTSB investigators assessed each of the 17 derailed hazardous materials tank cars.³³ Figure 11 is an example of a DOT-112 tank car. Nine of the tank cars, including four tank cars carrying anhydrous ammonia and five tank cars carrying methanol, showed breaching damage, summarized in table 4 and detailed in the following subsections.

Table 4. Material specifications of and damages to derailed tank cars.

Line no.	Car number/ commodity	Head thickness (in.)	Head material spec.	Shell thickness (in.)	Primary breaching damage
48	PROX45220 (Methanol)	0.531	TC128B	0.5	Not breached
49	UTLX971162 (Anhydrous ammonia)	0.9408	TC128B	0.9095	Not breached
50	TILX500864 (Anhydrous ammonia)	1.03	A516-70	0.89	Not breached
51	TILX500752 (Anhydrous ammonia)	1.03	A516-70	0.89	Not breached
52	TILX500890 (Anhydrous ammonia)	1.03	A516-70	0.89	Not breached
53	SHQX10732 (Anhydrous ammonia)	0.912	TC128B	0.922	Not breached
54	TILX500730 (Anhydrous ammonia)	1.03	A516-70	0.89	Liquid valve sheared off
55	TILX501050 (Anhydrous ammonia)	1.03	A516-70	0.89	8-inch thermal tear on the tank car's B end
56	UTLX971273 (Anhydrous ammonia)	0.9408	TC128B	0.9095	8.5-inch thermal tear on top of the tank car shell near B end

³³ CPKC provided clean certifications for each of the tank cars, indicating the interior of the cars had been purged of any toxic contents before the examination of the wreckage, and a contractor provided continuous air monitoring.

Line no.	Car number/ commodity	Head thickness (in.)	Head material spec.	Shell thickness (in.)	Primary breaching damage
57	TILX501231 (Anhydrous ammonia)	1.03	A516-70	0.89	Not breached
58	SHQX10754 (Anhydrous ammonia)	0.912	TC128B	0.922	Not breached
59	SHQX10805 (Anhydrous ammonia)	0.912	TC128B	0.922	4.25-inch thermal tear on top of the tank car shell near A end
60	CTCX300362 (Methanol)	0.4375	A516-70	0.4375	Manway gasket thermal damage ¹
61	TILX355610 (Methanol)	0.5625	TC128B	0.5625	-Shell fracture/ puncture on bottom of tank car near right side -Shell puncture near center of tank car on left side -PRD and vacuum relief valve sheared off
62	MFCX132265 (Methanol)	0.5	TC128B	0.5	-Puncture on tank car's A end above head shield -Puncture on tank car's B end below head shield -Liquid/vapor valves and PRD sheared off -Manway gasket thermal damage
63	CTCX300358 (Methanol)	0.4375	A516-70	0.4375	-21-inch shell tear near center of tank car on right side -17- and 27-inch shell tears on bottom on tank car near A end
64	CTCX732476 (Methanol)	0.4375	A516-70	0.4375	-Shell tear on left side on tank car near B end -Shell tear on bottom of tank car near B end -Liquid/vapor valves sheared off

¹ A *manway* is a general term for the circular-shaped opening located at the top of a tank car tank to allow access into the tank's interior. For non-pressure tank cars, the manway is typically closed with a hinged and bolted manway cover; pressure tank cars generally feature a semipermanently bolted manway cover or pressure plate.



Figure 11. DOT-112 tank car example.

1.4.1 DOT-112 Anhydrous Ammonia Tank Cars

The four derailed anhydrous ammonia tank cars that breached were US Department of Transportation (DOT)-112J500I (DOT-112) specification pressure tank cars. DOT-112 tank car specifications include a minimum burst pressure of 1,250 psig, a test pressure of 500 psig, and require a shell with a minimum plate thickness of 0.6875 inches.³⁴ The specifications also require a thermal protection system covered by a metal jacket and tank head puncture-resistance system. The manufacturers of the derailed DOT-112 tank cars were TrinityRail, Union Tank Car, and American Railcar Industries/Greenbrier (ARI).³⁵ Three of the derailed DOT-112 tank cars showed evidence of thermal tears—a longitudinal tank failure that occurs in the portion of the tank shell surrounding the vapor space of the tank during pool fire exposure—and one showed evidence of the liquid valve being sheared off.³⁶

³⁴ Requirements of tank cars transporting poison inhalation hazard (PIH) materials are established at 49 *CFR* 179.102-3 and further discussed in section 1.8.2.2.

³⁵ Although ARI was the builder of (59) SHQX10805 and other tank cars in train 242-03, its designs and operations were later acquired by The Greenbrier Companies.

³⁶ *Shear* forces act in opposing directions.

The PRDs used on each of the anhydrous ammonia tank cars involved in this derailment were REGO A8434FA series.³⁷ (See figure 12.) These shear-resistant low-profile PRDs are about 1 inch high and have a start-to-discharge pressure of 280.5 psig and a flow capacity rated at 3,549 standard cubic feet per minute (SCFM, nitrogen).³⁸

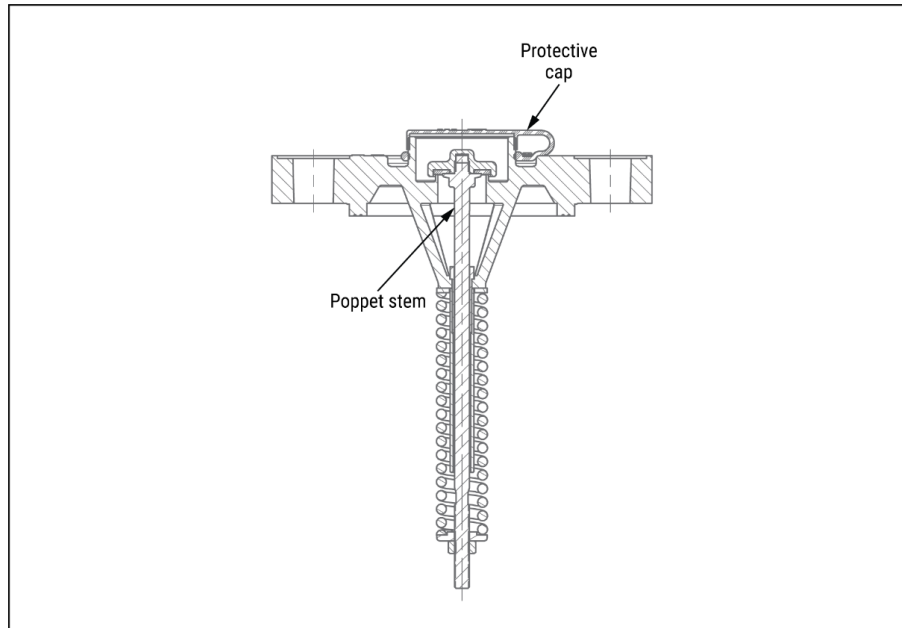


Figure 12. Diagram of the REGO A8434FA-series PRD.

The PRDs from the four breached anhydrous ammonia tank cars and one additional derailed anhydrous ammonia tank car were removed and sent to the National Board of Boiler and Pressure Vessel Inspectors (NBBI) Pressure Relief Laboratory in Worthington, Ohio, for examination.³⁹ The NTSB's post-derailment PRD examination reported the flow area of the PRDs to be about 0.809 square inches.⁴⁰

³⁷ The tank car manufacturer submitted certificates of construction for each of the tank cars to the AAR for approval. The certificates provide information on the PRD model chosen for the cars, the PRD start-to-discharge pressure rating, and the PRD required and actual rated flow capacities.

³⁸ (a) *Flow capacity*, also called venting capacity, is the capacity of a gas discharged at a required flow rating pressure. (b) The manufacturers of the tank cars derived PRD flow capacity requirements from 1,340 SCFM to 2,769 SCFM using a PRD selection criteria formula provided in Appendix A of the AAR's *Specifications for Tank Cars* (AAR 2024).

³⁹ See section 1.5.3 for more on PRD testing.

⁴⁰ *Flow area* is the cross-sectional area through which fluid or gas flows and is used to determine the flow capacity of a relief valve.

1.4.1.1 (54) TILX500730

Tank car (54) TILX500730 came to rest north of the tracks and rolled about 90° onto its right side, with its B end elevated above the A end.⁴¹ The protective housing and valves sheared off the car during the derailment.⁴² Nine of the bolts attaching the pressure plate to the manway nozzle had sheared off, as had all 20 of the pressure plate's 0.75-inch bolt studs attaching the protective housing to the pressure plate.⁴³ The liquid valve was missing from the pressure plate, and the vapor valve was bent. (See figure 13.) A CPKC remediation contractor observed anhydrous ammonia vapor leaking from the pressure plate.

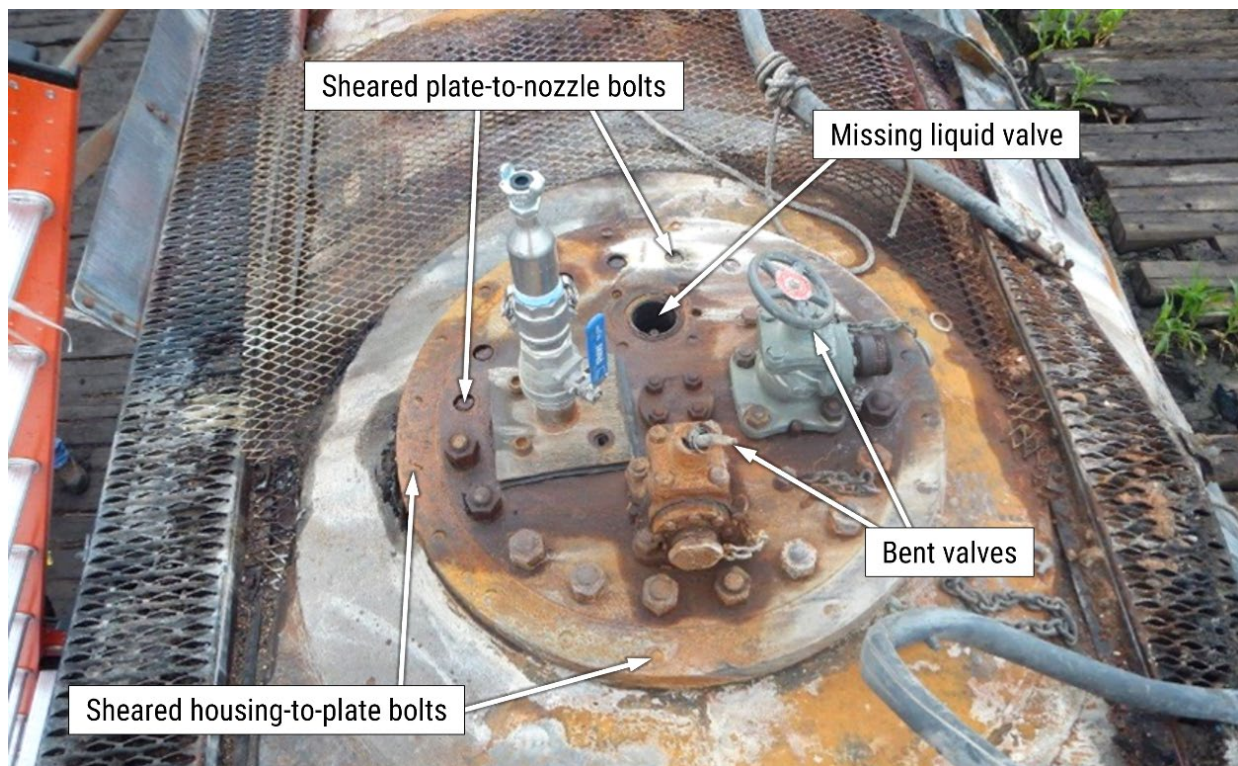


Figure 13. Damaged pressure plate and valves on (54) TILX500730. (Note: The PRD had been removed, and a transloading valve was installed in its place after the derailment.)

⁴¹ On a railcar, the *A end* is the end opposite the hand brake. The hand brake is mounted to the *B end*.

⁴² On pressure (and some non-pressure) tank cars, a circular steel *protective housing* surrounds fittings, valves, and components.

⁴³ A *pressure plate* is a bolted circular metal plate that closes the manway nozzle and to which the liquid and vapor valves, PRD, and protective housing are mounted.

1.4.1.2 (55) TILX501050

Tank car (55) TILX501050 came to rest south of the tracks, rolled about 10° onto its right side with its B end elevated above its A end. NTSB investigators observed a bulge and an 8-inch thermal tear in the shell on the tank car's B end. (See figure 14.) Additionally, blued steel was observed on the tank head and interior jacket surfaces near the thermal tear.⁴⁴ The paint was scorched on the top and sides of the tank shell and the left side of the B-end tank head. The FRA conducted ultrasonic thickness mapping of the tank steel at various points in the area of the tear. These measurements ranged from 1.092 inches to 0.479 inches closest to the tear.⁴⁵



Figure 14. B-end head bulge and tear.

NTSB investigators also observed the PRD poppet weather cover was missing.⁴⁶ The handwheels for the liquid and vapor valves and the interior surface of the tank car's protective housing cover were corroded.

⁴⁴ See section 2.2.2 for more on the significance of blued steel.

⁴⁵ The tank head was constructed with steel that was nominally 1.03 inches thick.

⁴⁶ A *poppet* is a sealing component within a PRD that is held against a valve seat by a compressed spring.

1.4.1.3 (56) UTLX971273

Tank car (56) UTLX971273 came to rest north of the tracks 20° on its left side, with its B end elevated above its A end, underneath a hopper car. NTSB investigators noted a bulge about 74 inches across the top and right side of the tank shell and an 8.5-inch thermal tear at the top of the tank shell. (See figure 15.) Ultrasonic thickness measurements near the thermal tear ranged from 0.905 inches to 0.474 inches.⁴⁷

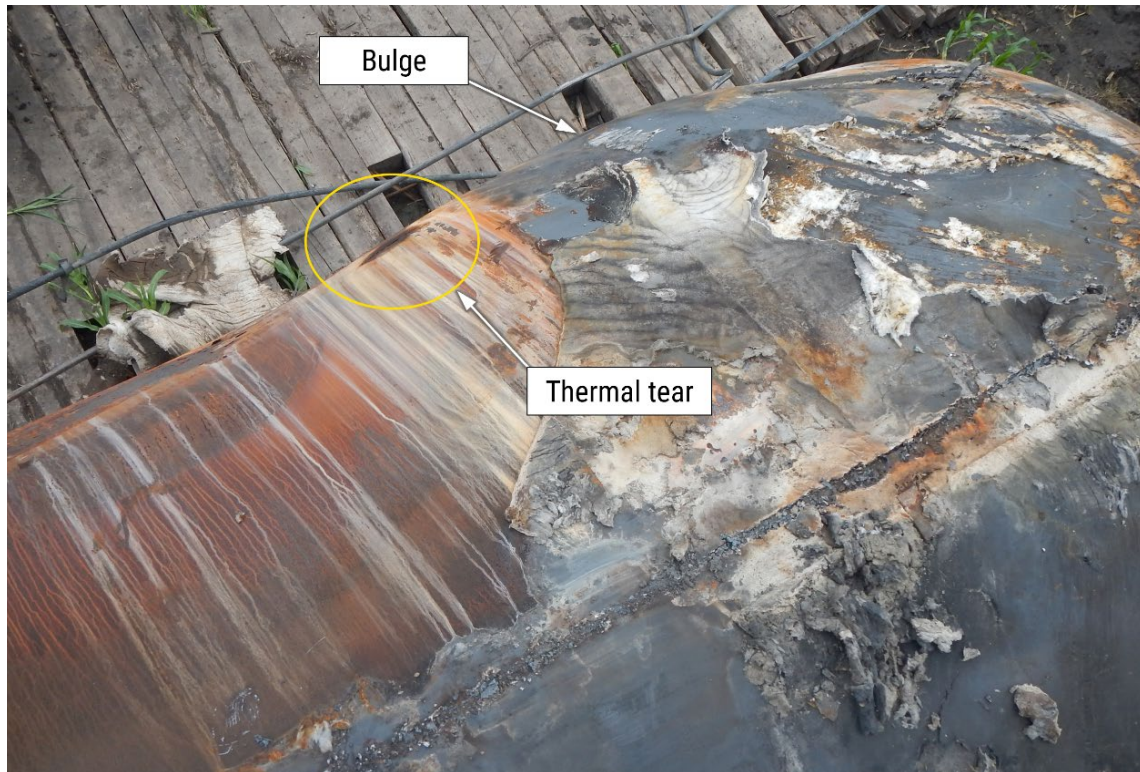


Figure 15. (56) UTLX971273 tear and bulge.

The tank car's protective housing and top fittings were intact. About half of the tank's surface had been exposed to fire: the thermal protection blanket was scorched, and the right side of the tank had scorched paint and orange-brown oxidation.

1.4.1.4 (59) SHQX10805

Tank car (59) SHQX10805 came to rest south of the tracks, rolled about 30° onto its right side and partially underneath a hopper car. NTSB investigators observed a bulge on one end of the car from the top to the left side of the tank shell and a 4.25-inch thermal tear on the left side. (See figure 16.) The tank shell jacket was

⁴⁷ The tank shell was constructed with steel that was nominally 0.910 inches thick.

torn and its thermal blanket missing.⁴⁸ Ultrasonic thickness measurements of the tank shell near the tear ranged from 0.948 inches to 0.415 inches.⁴⁹



Figure 16. Bulge in tank car (59) SHQX10805 (*upper left*) and thermal tear (*inset*).

Interior surfaces of the tank's A-end head shield showed multiple areas of blued steel. The thermal blanket also was scorched in this area. Paint was scorched on both sides of the tank, consistent with fire exposure across about 75% of the tank's surface. The top fittings' protective housing cover was missing, the housing was dented, and two corroded handwheels and a valve stem were detached and laying inside the housing. Additionally, the PRD was covered in melted plastic, and the rubber PRD weather cover was missing.

1.4.2 DOT-111 Methanol Tank Car

The DOT-111 is one of several non-pressure tank car specifications established in 49 *CFR* 179 Subpart D. The CPC-1232 enhanced specification DOT-111 tank car

⁴⁸ Emergency responders had placed a magnetic patch over the tear in this area.

⁴⁹ The tank shell was constructed with steel that was nominally 0.922 inches thick.

has no thermal protection system, a tank shell constructed of 0.5-inch Association of American Railroads (AAR) standard TC-128 Grade B steel, and half-height head shields bolted onto tank head mounting pads (AAR 2011). The specification does not require a full-height head shield or reclosing PRD, though DOT-111 tank cars may be equipped with these components to qualify for certain kinds of hazardous materials service or to improve survivability.

1.4.2.1 (62) MFCX132265

Tank car (62) MFCX132265, a CPC-1232 specification tank car, came to rest rolled about 45° onto its right side and with a hopper car laying across the B end. NTSB investigators observed a 3.5-inch puncture within a circular dent on the tank car's A-end head, above the half-height head shield, and a 4- by 13-inch, irregularly shaped puncture on the B end, just below where the half-height head shield had been. The B-end head shield was missing. (See figure 17.)

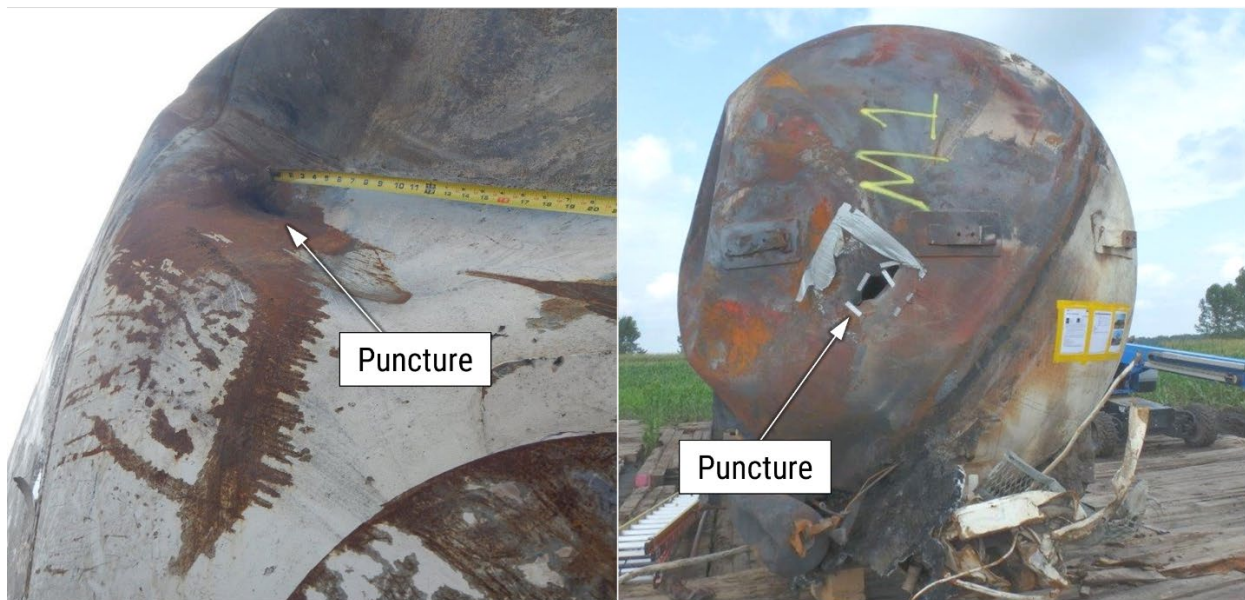


Figure 17. Punctures on the A end (*left*) and B end (*right*) of tank car (62) MFCX132265.

Additionally, the top fittings' protective housing was sheared off; the liquid valve, vapor valve, and PRD were missing; the manway gasket was destroyed; the bottom outlet nozzle was sheared off; and the ball valve remained closed. Dents on both sides of the tank car extended from the top of the tank shell to its bottom, with a gouge on one side and tank shell compression on the other.

1.4.3 DOT-117 Methanol Tank Cars

The DOT-117 tank car specification, established at 49 *CFR* 179.202, is a non-pressure tank car intended to offer improved survivability over the DOT-111 in derailments and fire conditions. The specification requires a minimum shell thickness of 0.5625 inches, full-height head shields, a thermal protection system with a jacket, top fittings protection, and a bottom outlet valve operating mechanism designed to prevent releases in derailment scenarios. DOT-117 tank cars, which can be retrofitted (DOT-117R) or newly built (DOT-117J), must meet the same thermal survivability performance requirements as pressure tank cars.

Of the five DOT-117 specification tank cars that derailed, one was a DOT-117J specification tank car ((61) TILX355610), and four tank cars ((60) CTCX300362, (63) CTCX300358, and (64) CTCX732476) had been retrofitted from DOT-111A100W1 specifications.⁵⁰ For each of these four tank cars, the retrofitting to DOT-117R involved adding a half-inch-thick ceramic fiber thermal protection blanket, tank jacket, half-inch-thick full-height head shields, top fittings' protective housing, and a bottom outlet valve handle designed to remain closed in derailment scenarios.

1.4.3.1 (60) CTCX300362

Tank car (60) CTCX300362 came to rest upright in the middle of the general pileup. Its manway cover gasket was absent. Some carbon fragments remained in the gasket groove. (See figure 18.) The shipper, Methanex Corporation, specifies that manway gasket material used in these tank cars must be made from ethylene propylene diene monomer (EPDM), a synthetic rubber.⁵¹

⁵⁰ The DOT-111A100W1 specifications included 0.4375-inch-thick ASTM standard A516-70 non-normalized steel tank heads, 0.4375-inch-thick AAR TC-128 grade B steel tank shells, and no thermal protection system or head shields. Non-normalized steel is less damage-tolerant than normalized steel, which has undergone a heat treatment process to refine its microstructure and enhance its mechanical properties.

⁵¹ EPDM generally has a maximum service temperature of 300°F. See <https://www.sealmaster.com/engineering/temperature-range-charts/>.



Figure 18. Manway cover on tank car (60) CTCX300362.

The tank car also had large dents on both the B-end head shield and the top of the tank shell, where a hopper car had come to rest. About half of the tank's surface had been exposed to fire, with scorched paint and red oxidation discoloration of the tank jacket steel across the surface, including near the manway.

1.4.3.2 (61) TILX355610

Tank car (61) TILX355610 came to rest about 45° on its left side, with a hopper car on top of it. The tank car had a 4- by 8-foot irregular fracture along one side of the tank shell, with a mass of melted plastic pellets inside of it, and a 6- by 8-inch puncture on the other side. (Figure 19 shows the shell fracture.) The PRD and vacuum relief valve were sheared off and missing from the car along with the top fittings' protective housing. More than half of the tank had been exposed to fire, and the tank car's placards were destroyed.



Figure 19. Shell fracture on tank car (61) TILX355610.

1.4.3.3 (63) CTCX300358

Tank car (63) CTCX300358 came to rest about 90° on its right side, generally parallel to the direction of travel. One side of the tank car had a 21-inch-long, irregularly shaped shell tear. The tank jacket was torn, and the thermal blanket was missing around the breach. The tank car also had 17- and 27-inch-long shell tears on the bottom of the tank, with a torn jacket and missing thermal blanket for several inches around the tears. (See figure 20.) More than 50% of the tank shell had been exposed to fire.



Figure 20. Tank car (63) CTCX300358 shell tears.

1.4.3.4 (64) CTCX732476

The final tank car to derail, (64) CTCX732476 came to rest about 90° on its right side across the track at the back (west) end of the pileup, its B end underneath a hopper car and its A end in contact with another hopper car. NTSB investigators noted irregularly shaped shell tears on the shell's side and bottom stretching the length of the tank car. (See figure 21.) The bottom of the tank car was deeply dented and compressed upward and its left side compressed toward its right side. The tank jacket was torn and peeled back, and the thermal protection blanket was missing in the same area, with the tank and tank shell exposed to fire.



Figure 21. Shell tear, torn jacket, and missing thermal blanket on CTCX732476.

1.4.4 AFFTAC Modeling

Thermal performance standards for tank cars transporting poison inhalation hazard (PIH) materials require a tank car to have sufficient thermal resistance so that no lading releases except through the PRD when the car is subjected to a fully engulfing pool fire for 100 minutes or a torch fire for 30 minutes.⁵² Compliance with these requirements must be verified by analyzing the fire effects on the entire surface of the tank car, while considering the fire effects on and heat flux through tank discontinuities, protective housings, underframes, jackets, insulation, and thermal protection.⁵³ The US DOT, Transport Canada, and tank car manufacturers currently use the Analysis of Fire Effects on Tank Cars (AFFTAC) software to model, evaluate, and qualify thermal protection systems.

AFFTAC inputs for both the pool fire and torch fire survival time simulations include nominal tank capacity, insulation thickness, PRD flow rate and start-to-discharge pressure, commodity properties, flame temperatures, and other variables.

⁵² (a) Thermal performance requirements are detailed in 49 *CFR* 179.18 and further discussed in section 1.8.2. (b) *Torch fire* generally describes a localized flame fed by a stream of fuel or gas.

⁵³ According to 49 *CFR* 179.18(b)(1), the procedures outlined in the 1984 FRA publication *Temperatures, Pressures, and Liquid Levels of Tank Cars Engulfed in Fires* are acceptable for analyzing the fire effects on the entire surface of the tank car.

If the AFFTAC analysis shows the thermal resistance of the tank car does not conform to thermal performance standards, the thermal resistance of the tank car must be increased by using a US DOT-listed system or by testing according to Appendix B of 49 *CFR* Part 179. The Pipeline and Hazardous Materials Safety Administration (PHMSA) maintains a list of thermal protection systems that comply with the requirements of Appendix B and no longer require test verification.

The thermal protection blanket on the TrinityRail-built DOT-112J500I tank cars involved in this derailment (line numbers 50-52, 54-55, 57, and 61), referred to in this report as PHMSA system application 05, appears on the PHMSA list of thermal protection systems exempted from test verification in accordance with 49 *CFR* 179.18(c).⁵⁴ TrinityRail did, however, provide an AFFTAC analysis report for the lot of tank cars constructed under AAR certificate of construction L126036A, which included tank car (55) TILX501050. The results of the AFFTAC modeling indicated the tank cars' designs surpassed the 100/30-minute survival requirements in both the upright and 120° overturned positions. The report stated the pool fire survival time was predicted to be greater than 200 minutes, while the torch fire survival time was predicted to be greater than 500 minutes.

For the Union Tank Car-built DOT-112 tank cars involved in this derailment, including tank car (56) UTLX971273, the car design was based on a previous approval that was identical in design and service equipment.⁵⁵ On May 13, 2016, Union Tank Car performed an AFFTAC analysis for the anhydrous ammonia tank car design in accordance with AAR's *Specifications for Tank Cars*. According to the AFFTAC report, there was no release of lading in the 100/30-minute simulations except through the PRD.⁵⁶

For the ARI-built DOT-112 tank cars involved in this derailment, including tank car (59) SHQX10805, ARI selected PHMSA system application 05 for its thermal

⁵⁴ PHMSA system application 05, FryeWrap Tank Car Blanket, formerly listed by PHMSA as Fiberfrax, is a 4.5 lb./ft³, half-inch-thick spun ceramic thermal blanket manufactured by Unifrax LLC (now Alkegen).

⁵⁵ The tank cars were designed under AAR certificate of construction L187042.

⁵⁶ For the pool fire AFFTAC simulations, given initial anhydrous ammonia liquid and vapor temperatures of 60°F at 92.7 psig, after 100 minutes of simulated pool fire exposure, the analysis indicated the vapor temperature was 466.4°F at a tank pressure of 169.1 psig with no actuation of the PRD. For the torch fire simulations, given identical initial tank conditions, after 30 minutes of simulated torch fire exposure, the analysis indicated the vapor temperature was 342.9°F with no increase in tank pressure or actuation of the PRD.

protection blanket.⁵⁷ On November 8, 2024, the Greenbrier Companies prepared an AFFTAC analysis report for the tank car specifications simulating a fully engulfing pool fire exposure for 300 minutes with the tank car oriented upright and for 144 minutes with the tank overturned 120°, as well as simulated 300-minute torch fire exposures in both upright and 120° orientations. The AFFTAC reports indicated no release of anhydrous ammonia except through the PRD during the 100/30-minute standard. In the 120° overturned orientation, the model predicted the tank would fail after 144 minutes of pool fire exposure, when the tank's pressure would equal its burst pressure.⁵⁸

1.5 Postaccident Tests and Evaluations

1.5.1 Track and Culvert Evaluations

NTSB investigators encountered severe track damage at the accident location, both from the derailment and from postaccident fire and hazardous materials release mitigation activities. The damage prevented NTSB investigators from examining the track in place in the immediate area of the accident. In postaccident inspections between July 5 and 16, 2024, FRA noted 27 track defects between MP 339 and 385, 10 of which were related to culverts.⁵⁹

On July 18, 2024, once debris from the derailment and cleanup operations had been removed, CPKC examined the two culverts at MP 343.4. NTSB investigators reviewed video taken during these examinations and identified recent damage and displacement from the derailment of three culvert segments: one segment on each

⁵⁷ (a) These tank cars were designed under AAR certificate of construction L-161000. (b) AITX is the owner of the SHQX-marked tank cars.

⁵⁸ The AFFTAC pool fire simulation report for an upright tank predicted that given initial tank conditions of liquid and vapor temperatures of 110°F at 250 psig, after 100 minutes the liquid temperature would have been 149.9°F and the vapor temperature 688.6°F, with PRD actuation after 9.5 minutes. After 300 minutes, the model predicted the liquid temperature would be 174.3°F, the vapor temperature 832.1°F, and the tank pressure 571.8 psig, the tank half empty from PRD venting. For a 120° overturned tank car in a pool fire, the report indicated that given the same initial temperature and pressure conditions, after 100 minutes, the liquid temperature would have been 184.9°F and the vapor temperature 786.5°F, with PRD actuation after 9.5 minutes. The model predicted that in the failure scenario 44 minutes later, the liquid temperature would be 221.9°F and the vapor temperature 831.1°F.

⁵⁹ FRA noted partial blockages of dirt, ballast, and silt in 6 of the 10 defects related to culverts. In the other four, FRA noted separations of culvert sections with ballast and dirt leaking through, similar to the accident culvert. FRA required the defects to be repaired within 30 days.

end of the west culvert and one segment on the north end of the east culvert. These damaged segments, numbered 1 through 5 from south to north in this report, were cleared away so the culverts could be examined further. Joints between the segments are labeled by culvert and by adjoining segments, for example, joint W1-2 is between segments 1 and 2 in the west culvert. (See figure 22.)

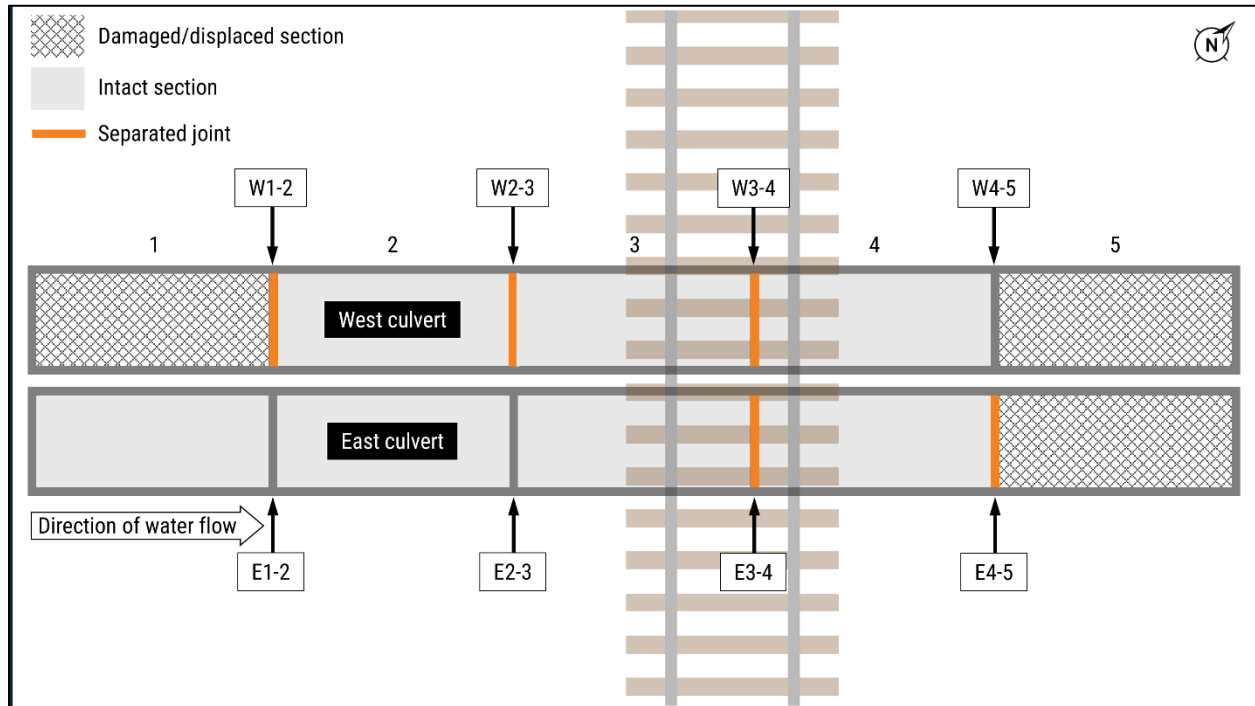


Figure 22. Layout of culverts at accident location, with damaged or displaced sections and separated joints noted.

Examinations indicated that both the east and west culverts were internally obstructed by ballast and roadbed material debris. Both culverts were partially filled with water at the time, so the examinations focused on the upper two-thirds of the structures. Before cleanout, ballast and soil blocked about 75% of the east culvert. (See figure 23.) The east culvert's joint E3-4—the joint between concrete segments 3 and 4—was open and displaced, with ballast and soil from above the culvert infiltrating the separation between segments. (See figure 24.) Circumferential rust streaks were present on the concrete of segment 4, parallel to the joint,⁶⁰ Most of the other joints in both culverts were covered by metal bands; a loose metal band of the same

⁶⁰ Metal bands are typically used as a nonstructural joint repair in a culvert's interior.

type was found near joint E3-4 during the examination. Joint E4-5 was also open and displaced, with the rocks and soil of the track bed visible through the separated joint.



Figure 23. East culvert upon examination and before cleanout.



Figure 24. East culvert at joint E3-4 looking south (*left*) and west (*right*). (Source: CPKC.)

The west culvert displayed several open joints. Segment 1 had been damaged in the derailment and Joint W1-2 was open and displaced, with the north end of segment 1 showing extensive derailment-caused damage and the south end of segment 2 showing minor material loss and cracking. On the north end of segment 2, missing concrete formed a large hole in the top of the culvert. Rusted reinforcing

steel could be seen in the hole, though some of the concrete cracking was light in color with clean fracture surfaces. (See figure 25.) Joint W2-3 was open about the length of the bell and displaced. As in the east culvert, a displaced and corroded metal band was loose near the north end of segment 3. The north end of segment 3 displayed some rust staining and circumferential cracking, which appeared to extend completely through the culvert wall. Further north in the west culvert, joint W3-4 was also open and displaced with extensive visible voids and signs of infiltration of ballast, rock, and soil. (See figure 26.) Portions of segment 4 near the top of the culvert were also missing.



Figure 25. Interior of west culvert looking north. (Source: CPKC.)



Figure 26. Interior of west culvert looking north (*left*) and west (*right*). (Source: CPKC.)

1.5.2 Wayside Signal Equipment Examinations

NTSB investigators examined all wayside signal equipment between CP Carrington East, CP 346, and CP Dry Lake West. The equipment was locked and secured with no indications of tampering or vandalism. Signal indications were in accordance with the physical location of the accident wreckage, and observations indicated that views of the signals were unobstructed. Investigators also reviewed data logs for wayside defect detectors at MP 358.0 and MP 383.9. Neither detector had logged mechanical defects with train 242-03.⁶¹

1.5.3 PRD Testing

On December 10, 2024, NTSB investigators observed testing at the NBBI Pressure Relief Laboratory of the five Rego A8434FA PRDs removed from derailed anhydrous ammonia tank cars. The testing determined parameters such as the start-to-discharge (opening) pressure and the venting or flow capacity (measured

⁶¹ Both detector locations functioned as hot bearing and dragging equipment detectors.

relieving rate at the full discharge pressure) in their as-received condition. The results of the tests are detailed in table 5.⁶²

Table 5. PRD pressure testing results.

Tank Car	Set pressure average (psig)	Popping pressure (psig)	Flow rate at 308.5 psig (SCFM)
(54) TILX500730	203.2	310.3	--
(55) TILX 501050	266.4	302.5	3384.9
(56) UTLX971273	--	313.5	3470.5
(57) TILX501231	--	303.4	3499.2
(59) SHQX10805	--	316.5	3423.0

Note: The valve on tank car (54) TILX500730 was not flow tested at 308.5 psig since the device had not achieved measurable flow by that pressure.

The tested flow capacities exceeded the required flow capacities as calculated by tank car builders TrinityRail, Union Tank Car, and ARI.

1.6 Hazardous Materials

1.6.1 Anhydrous Ammonia (UN1005, Class 2, Division 2.3)

Anhydrous ammonia is used for fertilizers, the manufacture of chemicals and synthetic fibers, refrigerants, cleaning solutions, pollution control, and other industrial uses. It is a hazard class (division) 2.3 poison gas, colorless and liquefied under pressure. Its vapor is lighter than air and at certain concentrations by volume in air is flammable, toxic by inhalation, and corrosive. (See table 6.)

Table 6. Anhydrous ammonia. (Source: CF Industries Safety Data Sheet.)

Property	Value
Physical state	Gas
Odor threshold ¹	1–50 parts per million

⁶² In its report, NBBI used the term “set pressure” instead of “start-to-discharge pressure.” Set pressure was defined as the PRD opening pressure at which the PRD began to leak one bubble per second from its outlet. Only the PRDs of tank cars (54) and (55) exhibited this behavior. The PRDs of the other three tank cars opened completely—popped—without any preliminary bubbles being observed.

Property	Value
Boiling point	−28.1°F
Vapor pressure at 68°F (20°C)	125 psig
Relative vapor density at 68°F	0.597
Lower explosive limit (by volume of air)	16%
Upper explosive limit (by volume of air)	25%

¹ The *odor threshold* of a material is the lowest volume or range of volumes at which humans can detect its odor.

Above its boiling point, released anhydrous ammonia vapor will expand to 850 times its liquid volume. It is corrosive upon contact to human tissue such as eyes, skin, mouth, throat, and lungs.

1.6.2 Methanol (UN1230, Class 3)

Methanol is a class 3 flammable liquid, used as a solvent, fuel, and feed stock for the manufacture of chemicals. Methanol liquid and vapor are highly flammable, and toxic if swallowed, in contact with skin, or inhaled.⁶³ (See table 7.) Incomplete combustion can release dangerous carbon monoxide and other toxic gases.

Table 7. Methanol. (Source: Methanex Safety Data Sheet.)

Property	Value
Physical state	Liquid
Odor threshold	4.2–5,960 parts per million
Flash point ¹	52°F
Vapor pressure at 68°F	1.86 psig
Relative vapor density at 68°F	1.1

⁶³ Ingestion of 10 ml of methanol can cause blindness and 30 ml can cause death.

Property	Value
Lower explosive limit (by volume of air)	5.5%
Upper explosive limit (by volume of air)	36.5%

¹ A flammable liquid's *flash point* is the temperature at which it produces sufficient flammable vapors to ignite in the presence of an ignition source.

1.7 Canadian Pacific Kansas City Railroad

Formed by the 2021 merger of Canadian Pacific Railway and Kansas City Southern, CPKC is categorized as a Class I railroad under Surface Transportation Board regulations in 49 *CFR* 1201.⁶⁴ CPKC operates about 20,000 route miles of track across Canada, the United States, and Mexico. It is headquartered in Calgary, Alberta, Canada.

1.7.1 Policies and Procedures

CPKC rules in effect at the time of the accident included the following, along with various general orders and special instructions:

- *US Eastern Region Timetable No. 1, 2024*, a publication containing information on the movement of trains in CPKC's Eastern region;
- *General Code of Operating Rules*, 8th Edition, 2020, a rulebook governing the operation of certain railroads, including CPKC;
- *Train & Engine Safety Rule Book*, 2023, CPKC's rulebook for operating employee safety;
- *CP Home Safe: United States Hazardous Materials Instructions for Rail, Version 1*, March 2022, CPKC's guidance for the safe transportation of hazardous materials by rail;

⁶⁴ The Surface Transportation Board categorizes rail carriers into three classes by operating revenue. In 2024, Class I carriers were those with an annual operating revenue of more than \$1.05 billion.

- *Emergency Response Guidebook, 2024*, a PHMSA manual for first responders to transportation incidents involving hazardous materials or dangerous goods;
- *CP Red Book of Track Requirements, 2024*, CPKC's standards for track inspection and maintenance; and
- *CP Red Book of Structures Requirements, 2023*, CPKC's standards for inspection and maintenance of bridges, culverts, retaining walls, and other structures.

1.7.2 Culvert Inspections

CPKC outlined its requirements for culverts and other structures under or near tracks in its *Red Book of Structures Requirements*. According to the *Red Book*, culvert inspections: (1) observe unobstructed hydraulic flow upstream and downstream of the culvert, (2) note changes in site conditions affecting drainage around the track structure, (3) ensure the structural integrity of the culvert and that no voids in the ballast or embankment were visible, and (4) identify necessary maintenance. CPKC required all culverts more than 36 inches in diameter to be inspected once every three years by a bridge inspector, unless "poor hydraulic or structural conditions" are observed, in which case the culvert must be inspected annually.⁶⁵ CPKC bridge inspectors receive specialized training related to bridges and culverts or have certain professional requirements.⁶⁶ CPKC's bridge maintenance manager told the NTSB that inspection crews, typically working in pairs, assessed about 2,000 culverts per year in their territory of about 700 main track miles.

The bridge maintenance manager stated that the culvert inspection process consisted of a visual inspection—looking into the ends of the culvert using a flashlight—provided the culvert was not filled with water.⁶⁷ In general, CPKC personnel evaluated and addressed culverts on an individual basis to determine

⁶⁵ Culverts that are less than 36 inches in diameter receive annual inspections from a track inspector and inspections every 5 years from a bridge inspector.

⁶⁶ These requirements include at least 3 years' experience in railway bridge maintenance or that the employee either hold a professional engineer license or the stricter qualification of bridge supervisor.

⁶⁷ The bridge maintenance manager stated that typical practice for culverts filled with water was to make sure the water was flowing and, if not, to "put something through them" to get the water to flow.

repairs and replacement schedules. Inspection reports were contained in CPKC's Structures Asset Management System and included ratings for each culvert's inlet and outlet as well as brief notes on any issues. Inspectors rated culverts using a numeric system, and required maintenance actions were programmed into the system software, as shown in table 8.

Table 8. Culvert condition ratings and actions.

Condition Rating	Description	Action
1	Very good	None
2	Good	None
3	Fair	None
4	Poor	Photo and text description required
5	Very poor	Photo and text description required Escalation to railroad bridge engineer
9	Needs immediate attention	Photo and text description required Escalation to railroad bridge engineer

The bridge maintenance manager indicated he was familiar with the culverts at MP 343.4 and with their ratings. In the 14 months between the May 2023 track repair and the accident, CPKC personnel had inspected the culverts at MP 343.4 twice: on September 20, 2023, and June 5, 2024. Tables 9 and 10 show the ratings of the east and west culverts for these dates, as recorded in CPKC reports.⁶⁸

Table 9. September 20, 2023, CPKC culvert inspection report.

Point	East	West
Channel	2	2
Vegetation	2	2
Blockage	3	1
Inlet condition	2	2
Inside condition	3 (blocked with ballast, clean out)	
Outlet condition	2	2

⁶⁸ The informal culvert inspection that took place as part of the May 2023 track repair was not contained in these records.

Table 10. June 5, 2024, CPKC culvert inspection report.

Point	East	West
Channel	2	2
Vegetation	2	2
Blockage	3	1
Inlet condition	2	2
Inside condition	3 (blocked with ballast, clean out)	
Outlet condition	2	2

After the June 2024 inspection, the bridge maintenance manager stated the culvert inspector told him that the east culvert was still blocked, and the manager slated the replacement of the culvert in the next year's scope of work for culvert repairs. The bridge maintenance manager noted that the basis for not rating the interior of the east culvert worse than 3 (fair) was that "it wasn't a complete blockage."

1.7.3 Position-in-Train Guidance for Hazmat

In the United States, AAR's *United States Hazardous Materials Instructions for Rail* (HMIR) offers general in-train placement guidance that can be adapted to the operating rules and practices of individual railroads. As CPKC's version of this document, CP Home Safe contains consistent and somewhat expanded guidance. The position-in-train chart in CP Home Safe contains four placard groups. Railcars within each group have different restrictions on which railcars they may be positioned next to in a train consist (CPKC 2022).⁶⁹ Tank cars transporting anhydrous ammonia and other PIH materials not in hazard zone A are placed in placard group B, which contains flammable gas, flammable liquids like methanol, and other hazard classes; these types of tank cars may be positioned next to each other.⁷⁰ CPKC uses software to evaluate the placement of the cars of each train for compliance with their position-in-train requirements.

⁶⁹ The AAR version of HMIR does not differentiate between US and Canadian shipments of anhydrous ammonia and does not instruct any separation from flammable materials.

⁷⁰ A *hazard zone* indicates one of four levels of hazard (A through D) assigned to gases as specified in 49 CFR 173.116. Gases in hazard zone A have the highest acute inhalation toxicity.

1.8 Regulatory Requirements

1.8.1 Track and Bridge Safety Standards

Federal regulations in 49 *CFR* Part 213 prescribe minimum safety requirements for railroad track, among these the requirement that drainage facilities under or immediately adjacent to the track bed be “maintained and kept free of obstruction, to accommodate expected water flow for the area concerned.”⁷¹ Regulations further prescribed requirements for qualified track inspectors to inspect main tracks on foot or by vehicle. For Class 4 main tracks, like the main track in the derailment area, these regulations required twice-weekly track inspections. Railroads are required to keep records of these inspections, which must include records of the location and nature of any deviation from the requirements outlined in 49 *CFR* Part 213 that were found.

1.8.2 Tank Car Standards

On January 13, 2009, PHMSA published final rule HM-246, *Hazardous Materials: Improving the Safety of Railroad Tank Car Transportation of Hazardous Materials*. The HM-246 interim tank car standards required enhanced tank head and shell puncture resistance.⁷² The thermally breached tank cars in this derailment were specification DOT-112J500I, with the letter “I” indicating interim design standards for a PIH tank car authorized by the US DOT.

On November 25, 2020, PHMSA published final rule HM-219C amending the Hazardous Materials Regulations (HMR) to revise 49 *CFR* 173.244(a)(2) and 173.314(c) to make the interim tank car specifications the final specifications for the transportation of PIH materials.⁷³ In the development of the final rule, PHMSA and the FRA concluded that the interim specification for PIH tank cars in final rule HM-246 provided significant improvement in accident survivability over the legacy designs.

⁷¹ See 49 *CFR* 213.33, “Drainage.”

⁷² The rule limited the use of interim-specification PIH tank cars for a period of 20 years from the date of construction. Title 49 *CFR* 173.31(e)(2)(ii) requires tank cars constructed on or after March 16, 2009, and used for the transportation of PIH materials to meet the applicable authorized tank car specifications and standards listed in 49 *CFR* 173.244(a)(2) or (3) and 173.314(c) or (d).

⁷³ Tank cars meeting the “I” standards will become DOT-105H500W, DOT-105H600W, or DOT-112H500W, respectively, at their next qualification, according to 49 *CFR* 179.22(e). The identifier “H” denotes compliance with permanent specifications.

The final rule established December 31, 2027, as the phase-out date for non-HM-246 standard tank cars.

1.8.2.1 DOT-111

The Fixing America's Surface Transportation Act (2015), or FAST Act, established a phase-out schedule to remove DOT-111 and similar tank cars from flammable liquids service (Public Law 114-94). By May 1, 2029, tank cars transporting flammable liquids must meet the newer DOT-117 specification.

1.8.2.2 DOT-112

Tank cars transporting Class 2 materials, including anhydrous ammonia, must be either specification 105H500W or 112H500W and must have thermal protection systems.⁷⁴ The performance standard provided by 49 *CFR* 179.18(a) states that when thermal protection systems are required, the tank car must have sufficient thermal resistance so there will be no release of any lading except through the PRD, when subjected to a fully engulfing pool fire for 100 minutes and a torch fire for 30 minutes.

Additionally, 49 *CFR* 173.314(b)(5) requires tank cars used for the transportation of anhydrous ammonia to have gaskets for manway cover plates and for mounting of fittings designed for temperature, application, media, pressure, and size to create a positive seal so that there will not be an identifiable release of material to the environment under normal transportation conditions. To reduce the potential of top fittings damage from shear forces that can occur during a derailment, 49 *CFR* 179.100-12(c) requires the shearing value of the bolts attaching the protective housing to not exceed 70% of the shearing value of the bolts attaching the underlying pressure plate to the nozzle. In addition, 49 *CFR* 179.102-3(a)(1) requires the tank car top fitting protection system and nozzle to be capable of sustaining a rollover accident in which the rollover speed (or linear velocity, oriented transversely) is 9 mph without failure.⁷⁵ Flow capacity requirements for tank cars that transport liquefied gases under pressure are incorporated by reference in 49 *CFR* 179.15(c).

⁷⁴ Requirements for the construction of DOT-112 pressure tank cars are established at 49 *CFR* Part 179, Subpart C, with additional design requirements for PIH materials at 49 *CFR* 179.102-3.

⁷⁵ In such an accident, the rolling protective housing strikes a stationary surface assumed to be flat, level, and rigid, and the rollover speed is determined as a linear velocity.

1.8.2.3 DOT-117R

The standard for DOT-117R tank cars—retrofitted from DOT-111 and CPC-1232 tank cars—requires tank shells to be constructed of a type of steel authorized by the HMR at the time of construction with a minimum thickness of 0.4375 inches.⁷⁶ Among the requirements for DOT-117R tank cars are tank head puncture resistance systems that must include full-height head shields that are at least one-half-inch thick and thermal protection systems conforming to 49 *CFR* 179.18.

1.8.2.4 DOT-117J

Requirements for the construction of DOT-117J non-pressure/general service tank cars used for the transportation of flammable liquids such as methanol are provided in 49 *CFR* Part 179, Subpart D. This tank car specification requires the tank shell to be made from normalized steel with a minimum plate thickness of 0.5625 inches, must have full-height head shields, and must have a tank test pressure of 100 psig.

1.9 Postaccident Actions

After the accident, CPKC retired the existing 48-inch circular concrete culverts, filling them with grout to block further water flow. CPKC installed two new 60-inch steel circular culverts underneath the track and graded surrounding ground surfaces to direct runoff through the new culverts.

CPKC also issued an engineering bulletin on August 4, 2025, notifying employees of a new culvert inspection job aid. The bulletin also encourages inspectors to conduct inspections using a waterproof action camera with an attached light, noting this tool “can be purchased on an as-needed basis” with director approval. The culvert inspection job aid lists 14 culvert conditions along with possible causes of the observed condition and actions to take. Table 11 contains examples of observations, possible causes, and fixes (remedies), as listed in the job aid.

⁷⁶ Requirements for DOT-117R retrofitted tank cars are established at 49 *CFR* 179.202-13.

Table 11. Excerpt from CPKC culvert inspection job aid, 2025.

Observations	Possible Causes	Fix
Sudden display of muddy or dirty conditions, sediment or interruption of flow. Increase or decrease of flow.	Upstream logging practices, development or other construction (new housing subdivisions), diversions, beaver.	Initiate track protection, notify the appropriate track supervisor immediately. Continue with investigation of causes.
Water backed up at culvert outlet and subgrade saturation.	Downstream blockage, Inadequate capacity of culverts downstream.	Remove debris to allow normal water flow. If major, initiate track protection.
Materials falling into pipe under load.	Open joints or holes in culvert. Slope instability.	Report the condition to the appropriate Structure Supervisor or Track Maintenance Supervisor immediately and continue with investigation of causes. If major, initiate track protection.

2 Analysis

2.1 Introduction

On July 5, 2024, about 3:36 a.m. local time, eastbound Canadian Pacific Kansas City Railroad (CPKC) freight train 242-03 derailed 29 railcars, including 17 hazmat tank cars, on the Carrington Subdivision near Bordulac, North Dakota. Methanol was released from some of the derailed tank cars, resulting in a pool fire that then led to releases of anhydrous ammonia from other derailed cars. There were no reported injuries, but a residence near the accident area was evacuated.

The analysis first examines factors that can be excluded as causal or contributory to the accident, discusses the accident sequence (section 2.2), and examines the following safety issue areas:

- CPKC's culvert inspection practices that are insufficient to identify culvert separation or a track bed vulnerable to collapse. (Section 2.3.)
- Standard for pressure relief devices (PRDs) that do not ensure the survivability of tank cars carrying poison inhalation hazard (PIH) materials. (Section 2.4.1.)
- Thermal protection system performance requirements that do not sufficiently protect against tank failures in tank cars used in PIH service. (Section 2.4.2.)
- Vulnerability to thermal damage of manway gaskets on tank cars used in flammable liquid service. (Section 2.5.)
- Standards and practices that allow tank cars in PIH service to be positioned next to tank cars carrying flammable liquids. (Section 2.6.)
- Hazards of the continued use of US Department of Transportation (DOT)-111 tank cars in flammable liquid service. (Section 2.7.)

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:

- *Weather and visibility.* Although it was dark outside at the time of the accident, the weather was clear with no precipitation and the locomotive's headlights illuminated the track ahead.
- *Track washout.* About 2 inches of rain had fallen in the preceding 24 hours, but this rainfall had mostly concluded about 6 hours before the accident

occurred. The investigation found no evidence that the water flow from the rainfall had exceeded the capacity of the culverts at the accident location.

- *Train 242-03 crew qualifications, impairment, and performance.* A review of CPKC qualification records showed that the crew was qualified. Postaccident toxicological testing was negative for impairing substances. Interviews with crew members and locomotive event recorder data indicated that the engineer's handling of the train leading up to and through the point of derailment was consistent with good train handling, and the NTSB noted no signs of operator-induced excessive in-train forces.
- *Mechanical condition of train 242-03.* Postaccident inspection of the non-derailed equipment and wayside defect detectors in the area of the accident showed no defects that were causal or contributory to the accident.
- *Signals and train control.* The signal and train control investigation determined train 242-03 was operating on clear signal aspects through the derailment area and that the positive train control system functioned as designed.
- *Tank car loading and securement.* No derailed hazardous materials tank cars were overloaded by weight or volume.
- *Mechanical damage resistance of DOT-112 tank cars.* NTSB investigators found no evidence of any mechanical breaching to anhydrous ammonia tank car heads or shells that would have resulted from puncture damage.
- *Evacuation actions.* The Carrington Fire Department (CFD) and Foster County Sheriff evacuation actions were timely and appropriate. Within 50 minutes of first notification, emergency responders evacuated a nearby residence downwind of the smoke and anhydrous ammonia plume.

Therefore, the NTSB concludes that none of the following issues caused or contributed to the accident: (1) weather and visibility; (2) track washout; (3) train 242-03 crew training and qualifications, toxicology, or performance; (4) mechanical condition of train 242-03; (5) signals and train control; (6) tank car loading and securement; (7) mechanical damage resistance of DOT-112 tank cars; or (8) evacuation actions.

2.2 The Accident

Train 242-03 departed Minot about 10:30 p.m. and, after leaving the siding at Carrington around 3:22 a.m., proceeded toward Bordulac. The train's event recorder data indicated an emergency application of the train's air brakes occurred at 3:36:51 a.m. The train crew told the NTSB that they felt and observed a train-line-initiated emergency braking application, after which the train came to a stop. The conductor recalled seeing a fireball behind the train, and the crew reported the emergency to the dispatcher.

2.2.1 Culvert Separation and Derailment

The NTSB's examinations of the east and west culverts that ran beneath the tracks at the accident site found that at some point before the accident, several sections of the 110-year-old west culvert had separated, causing gaps in the culvert walls through which soil and ballast entered the culvert itself. These gaps were notably large at joints W2-3 and W3-4, and NTSB investigators observed that ballast and rock from the track bed and soil from the surrounding ground had entered the culvert through these joints. The presence of ballast, rock, and soil inside the west culvert offered evidence of soil infiltration: subgrade material (soil) from around the culvert entering the culvert through the gap between sections, likely from water passing through and around the culvert. These sections, though separated, were structurally intact.

About a year earlier, in May 2023, CPKC crews repairing a crosslevel defect at the same location as the accident derailment observed a section of the track surface suddenly fall away. The east culvert displayed ballast and soil infiltration at that time, much like what was observed in the west culvert in 2024.

Data from locomotive CP8882's outward-facing camera and from earlier ATI inspections showed no apparent surface defects in the track bed itself as the train approached the derailment site on July 5, 2024, suggesting that the loss of ballast and subgrade was concentrated beneath the track structure. (See figure 27.) The sudden downward collapse of the track bed as the train passed over the culvert at the time of the accident indicated that the loss of ballast material through a separation in the culvert sections had at some point created a subgrade void above the culvert which gave way as the train went over it.

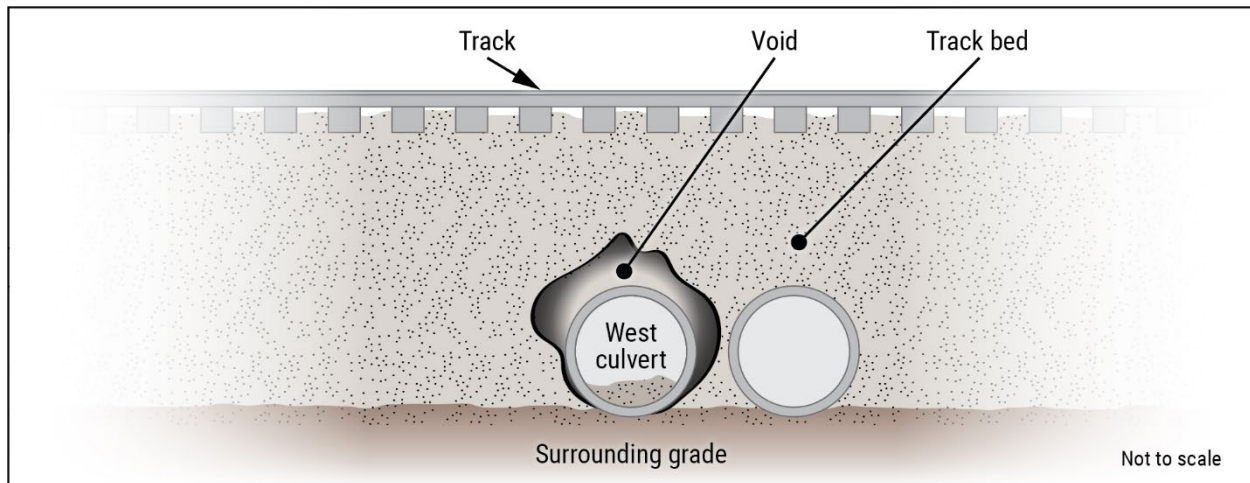


Figure 27. Illustration of subgrade void and culverts.

Water flow around and through the culvert had likely caused the void to grow larger over time, but the remaining fill material and ballast above the void likely acted as an “arch” to support the track bed. Over time, however, with the loss of material, the subgrade could no longer transmit the applied loads around the void, and the void collapsed under the accident train.

In postaccident examinations, NTSB investigators observed the following evidence that the last 11 railcars on train 242-03 to traverse the culvert location before the derailment had passed over a severe dip in the tracks, and that the last 7 of these railcars had traversed a broken rail:

- Witness marks on the axles of railcars line 36 through 39 from contact with the railcar’s draft sills;
- Witness marks on the wheels of railcars line 40 through 43, 45, and 46 from contact with a broken rail; and
- Broken buffer castings on railcars line 45 and 46.

Tracks are designed to transmit the loads from the train’s wheels to the rails, then into tie plates, crossties, ballast, and finally the subgrade. The pattern of witness marks on the axles of the 36th through the 39th railcars indicated a sudden loss of vertical track support, which initiated an extreme vertical profile condition (a dip) on the surface of the rails. The axles struck the railcar’s draft sills as the trucks passed over the newly formed dip and pitched up and down. (See figure 28.)

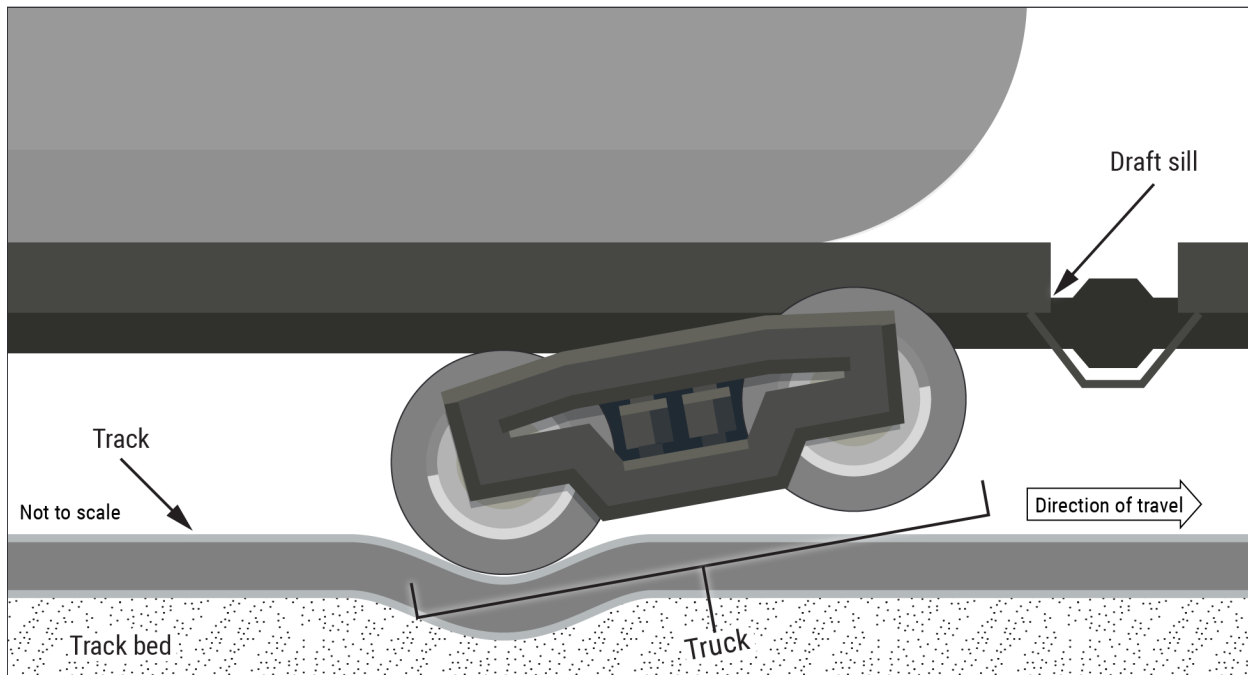


Figure 28. Illustration of the movement of railcar trucks, showing axle contact with draft sill.

When a train traverses rails that lack vertical support from ballast, the loads on the rail can exceed a rail's strength and result in a rail break; then, as the train traverses a broken rail, railcar wheels impact the broken rail ends, leaving witness marks. The pattern of witness marks on the wheels of the railcars indicated that the south rail likely broke as railcars 39 and 40 passed over it—after the void collapsed and as the railcars were negotiating the extreme dip in the rails. Therefore, the NTSB concludes that the sudden collapse of the void in the subgrade supporting the track at MP 343.4 initiated a dip in the rails, and as the 39th and 40th railcars traversed the dip, the applied forces from train 242-03 likely caused the south rail to break.

NTSB investigators observed broken buffer castings on railcars line 45 and 46, evidence that the severe dip traversed by railcars was worsening. As train 242-03 traversed the dip and broken south rail, the railcars twisted longitudinally toward the south. On the trailing end of the train's 47th railcar (the final railcar to traverse the broken rail without derailling), NTSB investigators observed a broken knuckle. Railcars line 47 and 48 (and the air brake hoses between them) separated because of the broken knuckle, and railcars line 48 through 76 derailed. The remaining railcars came to a stop from the train brake application once cars 47 and 48 separated. Therefore, the NTSB concludes that the 48th through 76th railcars on train 242-03 derailed because the train traversed a broken rail with no track bed support.

2.2.2 Hazardous Materials Release

Nine of the derailed tank cars sustained breaching damage: four anhydrous ammonia tank cars and five methanol tank cars. Only one of the DOT-112 anhydrous ammonia tank cars, (54) TILX500730, sustained mechanical breaching damage when the tank car rolled onto its side and struck another tank car, causing the protective housing of the top fittings pressure plate to separate from the plate itself.⁷⁷ When the bolts attaching the pressure plate to the nozzle sheared off, likely from incidental lateral movement of the separated protective housing, they created a leak pathway for the release of anhydrous ammonia at the point where the pressure plate connected to the nozzle.⁷⁸

The five breached methanol tank cars included three DOT-117R tank cars retrofitted from legacy DOT-111 tank cars, one newly built DOT-117J tank car, and one DOT-111 tank car built to the CPC-1232 industry standard. One of the DOT-117R methanol tank cars, (60) CTCX300362, released lading through a thermally damaged manway gasket, described in further detail in section 2.5. The other two DOT-117R tank cars, (63) CTCX300358 and (64) CTCX732476, sustained complex fractures, tears, and punctures across their tank shells from the impact of the oncoming railcars, and through these breaches, they each released about 28,000 gallons of methanol. The DOT-117J tank car (61) TILX355610 released its entire 26,000-gallon methanol lading through a puncture on its left side and a large shell tear on its right side that was caused by two trailing plastic pellet hopper cars (the final cars to derail) overriding the tank car.⁷⁹ Video evidence indicates that (62) MFCX132265, the DOT-111 tank car, released its methanol lading through head punctures on each

⁷⁷ Besides thermal breaching, tank cars can also fail through other mechanisms, including mechanical breaching (caused by external forces, such as a puncture from a rail or coupler) or a boiling liquid expanding vapor explosion (called a BLEVE and caused by the catastrophic, explosive rupture of a pressurized vessel containing a liquid stored above its atmospheric boiling point).

⁷⁸ As required by federal regulations, the shearing value of the housing-to-plate bolts was less than that of the plate-to-nozzle bolts, so the release most likely resulted from a loss in sealing pressure or securement of the plate rather than from mechanical nozzle damage. Although the tank car's liquid and vapor valves were damaged, the eductor pipe check valves may have controlled the release of anhydrous ammonia through that pathway.

⁷⁹ (a) Because of the trailing tonnage run-in from the lengthy train, which provided the hopper cars sufficient force to gouge and rip the tank shell of tank car (61) TILX355610, the DOT-117J derailment damage resistance specifications were not a major factor in the tank car's survivability. (b) The protective housing for the top fittings on the tank car was sheared off, leaving a leak pathway in the pressure plate (had the lading not already released through the shell tear).

end; the tank car's top fittings were also sheared off in the derailment. The damage performance of that tank car is further detailed in section 2.7.

The released methanol lading ignited and resulted in a pool fire surrounding the derailed railcars.⁸⁰ Two of the hopper cars containing plastic pellets also breached as a result of the derailment, further supplying combustible material to fuel the fire, which also spread to the other derailed plastic pellet hopper cars.⁸¹ Thermal tears were found on three DOT-112 anhydrous ammonia tank cars: (55) TILX501050, (56) UTLX971273, and (59) SHQX10805, each further discussed in section 2.4. These longitudinal ruptures were surrounded by bulges and tank shell material that in each case had thinned to about half its nominal thickness near the lip of the tears. Scorched thermal protection blankets as well as orange-brown oxidation and blued steel was observed in the tank car shells near the tears, indicating exposure to very high temperatures.⁸² Based on the examination of the breached tank cars, the NTSB concludes that the five breached methanol tank cars supplied fuel for a fully engulfing pool fire that led to thermal breaching of three of the adjacent anhydrous ammonia tank cars.

CPKC models of the anhydrous ammonia vapor plume were consistent with the plume's actual southeasterly path that was observed on video evidence, which showed a dense white vapor cloud in a V pattern, relatively low to the ground, that appeared to dissipate over puddled water and nearby wet agricultural field. Because anhydrous ammonia is attracted to water, the surface water in the area and water mist sprayed by emergency responders during suppression activity helped dissipate and attenuate the chemical cloud.

2.3 Insufficient Culvert Inspection Practices

In this accident, the track bed collapsed because a degraded culvert below the tracks caused the loss of subgrade material. No more than 13 months had elapsed between inspections of the culverts at MP 343.4, making their inspection frequency well within CPKC's culvert inspection program requirements of every 3 years. CPKC

⁸⁰ The available evidence did not indicate a specific ignition source for the pool fire in this accident.

⁸¹ The anhydrous ammonia releases did not contribute to the severity of the pool fire because although anhydrous ammonia is flammable, it is only so at a temperature too high to be likely in an outdoor release scenario.

⁸² Blued steel suggests the development of a blue oxide layer, indicating the tank steel in this region sustained exposure to temperatures of at least 600°F.

conducted regular track inspections as required by federal regulation and operational policy, including within 24 hours of the accident. However, neither the track inspections nor the culvert inspections gave CPKC personnel any indication of the unsafe condition below the rails in the subgrade.

The typical culvert inspection practice, as defined by the CPKC bridge maintenance manager, was to peer into the ends of the culvert with a flashlight to assess their condition, as well as inspecting the condition of culverts inlets, outlets, and flow channels. The culverts at the accident location were 48 feet long. Because of the culverts' length, a view from their ends would be limited to a narrow angle, and the middle of the structure would be obscured by distance. Figure 29 shows how the view from the end of the culvert does not offer a view of the culvert joints and could prevent an inspector from seeing the joint separation.



Figure 29. Joint E3-4 viewed from the end (*left*) and inside (*right*) the east culvert.

Inspection reports for both culverts from both September 2023 and June 2024 contain a series of ratings. These ratings are discussed in greater detail below, but in general, the culvert conditions were recorded variously as "fair" to "very good," with a note added to the records indicating a ballast blockage in the east culvert. The NTSB's postaccident examinations of the culverts found separations and infiltration of ballast into the culvert, indicating that the culverts were in much worse condition than their inspection records suggested. Therefore, the NTSB concludes that although the frequency of culvert inspections was sufficient to detect adverse conditions, CPKC's

method of culvert inspection—observing the culverts from their ends—did not allow inspectors to fully assess or quantify the condition of the culverts because of the narrow and limited viewing angle.

The American Railway Engineering and Maintenance-of-Way Association (AREMA), a professional association that produces and publishes recommended practices for railway engineering infrastructure, notes in its *Manual for Railway Engineering* that a primary cause of poor culvert performance is a lack of knowledge of installation, maintenance, and inspection. AREMA affirms that “it is usually necessary to perform an internal inspection of the conduit”—that is, physically entering the culvert or using a device to record imagery of the inside of a culvert—to properly evaluate its structural integrity (AREMA 2025). AREMA notes, however, that these inspections can present hazards to personnel (for example, from debris or from culverts that are too small for an inspector to safely enter) and suggests technologies such as specially designed video cameras, deflection recording devices, and crack measuring devices to facilitate safe and comprehensive culvert inspections.

In August 2025, CPKC issued an engineering bulletin to employees that encouraged the use of cameras with lighting capability to facilitate better inspections, noting that they can be purchased by their inspectors on an as-needed basis with director approval. A camera with lighting capability is a useful tool, but the bulletin does not require internal culvert inspections and does not require supervisors to provide cameras, other technology or methods for inspectors to use, as suggested for railroads by AREMA. Therefore, the NTSB recommends that CPKC revise its culvert inspection procedures to require every culvert be inspected internally, either on foot when safe or by using technology, such as cameras or remotely operated vehicles.

CPKC’s Structures Asset Management System requires their inspectors to evaluate and classify the condition of culverts using numeric values of 1 through 5 and 9. (See table 8.) For poorly rated culverts (4, 5, and 9), CPKC’s system required the inspector to attach a photo of the problem and, if necessary, alert a bridge engineer to the condition. This system provides limited explanation to inspectors on how to assign the numeric ratings; however, the numbers simply correlate to one- or two-word descriptions (“very good” through “very poor”). The NTSB found no written guidance from CPKC for inspectors to assess specific conditions—such as for a complete blockage—and minimal guidance to inform the basis for each number in its culvert rating system.

In the bridge maintenance manager’s interview with the NTSB, he explained the basis for one of the east culvert’s ratings of 3 (“fair”), stating that it was due to the

blockage first observed during a repair project in May 2023 and that the debris didn't completely block the culvert. In a photograph taken during the project, however, the blockage appears complete, with no light visible through the culvert past the debris. The NTSB was unable to identify CPKC's criteria for a rating of 3—or any of the other numeric ratings. Thus, the blockage in the east culvert, which dated back to at least spring 2023, could garner a “fair” rating that required no action, because bridge inspectors received limited guidance on how to select appropriate ratings.

Without established criteria to assess the condition of culverts, inspectors lacked the tools to effectively describe what they found, and the limitations of CPKC's rating system resulted in incomplete culvert assessments. The track structure's May 2023 failure—a similar failure to the one that caused the track bed collapse and derailment—indicated an ongoing problem. A more accurate assessment of the culverts' conditions would have incorporated information about the joint separation and soil and ballast infiltration. Given the 2023 failure, such an assessment could have alerted CPKC's bridge maintenance team of the serious conditions of the west culvert that could lead to sudden failure and make its repair a priority. The NTSB, therefore, concludes that because CPKC's culvert inspection program did not offer substantive guidance to inspectors on how to rate specific conditions, the east and west culverts' ratings did not reflect the serious conditions—a complete blockage with separations in one and culvert separations and soil infiltration in the other—that should have required appropriate and timely remedial action.

FRA does not have requirements for culvert safety inspections and maintenance standards separate from the track safety standards in 49 CFR Part 213. The AREMA *Manual* provides recommended practices to railroads on culvert inspection, however, and refers railroads to the American Association of State Highway and Transportation Officials' (AASHTO's) *Culvert & Storm Drain System Inspection Guide* for details about culvert inspection items and techniques. AASHTO's *Guide* contains a section on condition rating systems, with detailed descriptions of culvert conditions, example photographs, and rationale for rating specific culvert conditions.

In its August 2025 bulletin, CPKC introduced a culvert inspection job aid that lists 14 culvert conditions, their potential causes, and actions to take based on the observed condition. The railroad's job aid does not offer rationale for CPKC's numeric ratings but instead appears to supplement them, identifying certain conditions for timely maintenance action. Although the job aid offers direction for actions to take based on the conditions listed, it is much less specific than the guidance offered by AREMA and AASHTO. Further, CPKC's job aid includes no system for prioritizing remediation actions. CPKC's efforts to aid inspectors can be further improved by

outlining specific details about possible culvert conditions, similar to how these are addressed in AASHTO's *Guide*. Therefore, the NTSB recommends that CPKC revise its culvert inspection procedures to provide detailed rating guidance, specific to each type of culvert construction, similar to AASHTO's *Guide* as recommended by AREMA, and require remedial actions to be taken within set timeframes, when necessary.

Culverts like the ones at the accident location are part of every rail carrier's infrastructure and must be maintained to ensure the structural integrity of the tracks above them; like the accident culverts, many are decades old. The AAR and the American Short Line and Regional Railroad Association (ASLRRA) can play a critical role in raising awareness among other railroads about the importance of internal culvert inspections and detailed guidance for culvert inspectors. Therefore, the NTSB recommends that the AAR and ASLRRA inform their members of the circumstances of this derailment and encourage them to (1) review and revise as necessary their culvert inspection procedures to include a requirement to perform internal inspections either on foot when safe or by using technology, such as cameras or remotely operated vehicles, and (2) provide detailed rating guidance specific to each type of culvert construction, similar to AASHTO's *Guide* as recommended by AREMA, and require remedial actions to be taken within set timeframes, when necessary.

2.4 DOT-112 Tank Car Shell Tears

Along with being one of the first major derailments involving a hazmat release the NTSB has investigated since the 2023 Norfolk Southern Railway derailment in East Palestine, Ohio, this accident is also one of the first we have investigated involving the performance of DOT-112 specification tank cars.⁸³ Representing a newer generation of tank cars for PIH materials, DOT-112 tank car design standards were developed in response to NTSB safety recommendations derived from fatal railroad accidents in Minot, North Dakota, in 2002 and Graniteville, South Carolina, in 2005 (NTSB 2004, NTSB 2005). In the Minot accident, a Canadian Pacific Railway freight train derailed, and 11 tank cars released anhydrous ammonia, creating a vapor plume that killed one person and injured more than 300. In Graniteville, a Norfolk Southern Railway freight train collided with a parked train; in the resulting derailment, a tank car loaded with liquefied compressed chlorine was punctured by the coupler of an adjacent

⁸³ A few months before the Bordulac derailment, in April 2024, a BNSF Railway mixed freight train derailed in Manuelito, New Mexico, and four DOT-112 tank cars breached and released liquefied petroleum gas (NTSB 2025a). Two of the tank cars were mechanically breached, but tank cars UTLX954193 and NATX40068 released lading from shell tears after being exposed to fire. Ultrasonic measurements showed that the shell wall had thinned and cracked near the tears, suggestive of thermal tears.

freight car. The breached tank car released chlorine gas, which killed 9 people and hospitalized 75.

In the years following the Minot and Graniteville accidents, PHMSA developed regulations and tank car design enhancements to address deficiencies in mechanical damage resistance, enhancing impact resistance, and requiring thermal protection for some commodities. In response to our recommendations addressing the insufficient crashworthiness of PIH tank cars, PHMSA issued an interim tank car standard in 2009 and a final standard in 2020.⁸⁴ The interim standard (also known as HM-246 for the final rule by that number) established enhanced commodity-specific design standards for PIH tank cars, which required newly built tank cars to use normalized steel with increased head and shell thicknesses, full head shields, and improved top fittings protection systems (74 FR 1770).⁸⁵

At the time, PHMSA made it clear that the HM-246 requirements would only serve as interim standards until follow-up research could lead to final performance standards that would further improve accident survivability. In final rule HM-219C, PHMSA accepted HM-246 as the final standard for PIH tank cars without any further modification (85 FR 75680).⁸⁶ Final rule HM-219C requires phaseout of earlier PIH tank car designs and requires such materials to be shipped in HM-246-compliant tank cars by January 1, 2028. The HM-246 standard addressed enhanced impact resistance and required thermal protection for some commodities, such as Class 2 gases including anhydrous ammonia, but did not enhance the PIH tank car fire survivability standards outlined in 49 *CFR* 179.18.

All the derailed anhydrous ammonia tank cars at Bordulac conformed to the HM-246 design criteria. NTSB investigators found no evidence of any mechanical breaching from punctures to the anhydrous ammonia tank car heads or shells, but on

⁸⁴ NTSB safety recommendations R-04-4, R-04-5, R-04-6, and R-04-7 were issued to the FRA in March 2004. Recommendations R-04-4 and R-04-5 were both classified Closed – Unacceptable Action in August 2010. Recommendation R-04-6 was classified Closed – Acceptable Action in January 2011, and recommendation R-04-7 was classified Closed – Acceptable Action/Superseded in February 2019.

⁸⁵ For more detailed background information on DOT specification tank cars for the transportation of PIH materials and other DOT specification tank cars that have survived pool fire exposures in derailment scenarios, see “Hazardous Materials and Emergency Response Group Chair’s Factual Report–Supplemental” in the [public docket](#) for this investigation.

⁸⁶ PHMSA agreed with the conclusion of the Advance Tank Car Cooperative Research Project that no design feature or material could be identified that would provide a significantly greater level of improvement or would be a reasonable alternative from an economic and manufacturability standpoint.

(54) TILX500730, the protective housing had sheared away from the top of the tank car and separated from the pressure plate, likely from the protective housing striking another railcar as the tank car rolled onto its side in the derailment. Three of the tank cars, each constructed by a different manufacturer to the same DOT-112 specification, displayed thermal tears: (55) TILX501050, (56) UTLX971273, and (59) SHQX10805. The thermally caused breaches in these tank cars were nearly identical in both size and location, suggesting a design issue may have caused these failures.

NTSB investigators reviewed drone video footage and visual evidence collected by emergency responders but could not determine the precise timing of the breaching events. The drone video footage was not recorded until hours after the derailment when thick black smoke and pool fire flames obscured views of the locations of the tank cars that developed thermal tears. Firefighters recalled first noticing the odor of ammonia south of the tracks about 89 minutes after the derailment occurred, although it is unknown whether a thermal tear had occurred or if the odor was due to the normal operation of the anhydrous ammonia tank cars' PRDs. When first responders permitted site access, CPKC contractors first confirmed an anhydrous ammonia leak at 7:55 a.m. on July 6, 2024, more than 28 hours after the derailment. Therefore, the investigation could not determine whether the thermal protection systems on the three thermally breached anhydrous ammonia tank cars met the 100/30-minute survival benchmark prescribed in 49 *CFR* 179.18(a).

The tank car manufacturers—TrinityRail, Union Tank Car, and ARI—conducted AFTTAC fire simulation modeling during development that predicted the tank car designs would meet the 100/30-minute survival benchmark; one model predicted that the tank would fail in certain pool fire conditions after 144 minutes. The ultimate burst strength of a tank is directly influenced by the temperature of the tank shell because high temperature significantly lowers the tensile strength of carbon steel. As the temperature of tank car steel rises above 750°F (which commonly occurs in a hydrocarbon pool fire), the material begins to lose strength; above 1,150°F, the tank wall is likely to rupture within only a few minutes (Birk 2005). If the pressure relief capacity of the tank car PRD is not sufficient, the increasing temperature in the vapor space increases the pressure within the tank and accelerates the yielding of the shell material, which stretches until a through-wall crack forms.

2.4.1 Pressure Relief Devices

Under federal regulations, tank cars carrying PIH materials such as anhydrous ammonia must have reclosing PRDs and a thermal protection system that conform to

the requirements of 49 *CFR* 179.18, including the 100/30-minute survival benchmark. According to the FRA's *Railroad Tank Car Relief Valve Requirements*, the PRD must be properly sized with an appropriate flow capacity and start-to-discharge pressure (to control the release of pressure in a tank), and the tank car must have a thermal protection system (to control the rate at which temperature, and therefore pressure, increases).

Reclosing PRDs of the type used on the thermally breached tank cars open and close by design, limiting the amount of lading released in a fire exposure incident. Selection of PRD flow capacity and start-to-discharge parameters must weigh the risk of injuries and fatalities from PIH material released through the PRD against the risk of a structural failure of the tank car caused by insufficient pressure relief—a risk that, in the worst case, results in an instantaneous release of a tank's entire contents of toxic material. In an ideal scenario, an open PRD quickly releases lading, vapor, or both, reducing tank pressure and allowing the PRD to reclose. Then, if the external fire continues to burn, pressure rebuilds within the tank and the release cycle repeats, keeping the internal pressure from rising higher than that required to open the PRD.

The volume inside a tank car is comprised of liquid lading and unfilled vapor space. When a tank car is involved in a pool fire, the tank shell and its contents will increase in temperature. The temperature of the tank shell area holding the vapor space typically increases at a much faster rate than the temperature of the tank shell area holding the liquid lading. This is due to the thermal mass of the lading. The tank shell material in the vapor space area can reach temperatures sufficient for the pressure to form bulges in the shell material, resulting in localized thinning of the shell material. Experience has shown that bulges with thinned shell material are most likely to occur in the higher (raised) end of a tank car that has derailed—the end furthest from the liquid lading—because the tank surfaces that are wetted by the liquid inside the tank tend to remain at a temperature close to that of the liquid.⁸⁷

The physical characteristics of different toxic chemicals necessitate that the containers they are transported in meet safety requirements to mitigate the risk of release. PRD parameters should therefore account for the toxicity and physical characteristics of the specific PIH material. Anhydrous ammonia has a high coefficient of thermal expansion, meaning it expands with increasing temperature at a much faster rate than many other liquefied commodities. In a tank, even a slight rise in temperature will result in a large pressure increase. To prevent tank failure from a

⁸⁷ For example, see the [docket](#) for the NTSB's assessment of tank car thermal performance for a 2015 CSX derailment and crude oil release and fire in Mount Carbon, West Virginia, in 2015.

pressure buildup, federal regulations at 49 *CFR* 179.15 require tank car PRDs with sufficient flow capacity and with a start-to-discharge pressure that is no more than 33% of the tank's burst pressure. The DOT-112 tank cars involved in this accident therefore had burst pressures of 1,250 psig and start-to-discharge pressures of 280.5 psig. The vapor pressure of liquid anhydrous ammonia produced within a tank is equivalent to the 280.5 psig start-to-discharge setting at a liquid temperature of about 122°F (DOC 1923). A slight rise in temperature and corresponding pressure above this value causes the PRD to open fully to exhaust anhydrous ammonia from the tank car, reducing the pressure in the tank. If the PRD's flow capacity is adequate, the liquid temperature will tend to remain relatively constant as it is vaporized and expelled from the tank; if the PRD flow capacity is insufficient, the liquid temperature and the pressure in the tank will continue to rise even while the PRD is venting, and thermal tears can occur.

After the derailment, the three thermally breached anhydrous ammonia tank cars came to rest rotated longitudinally onto their sides: tank car (55) TILX501050 had rolled onto its side about 10°, tank car (59) SHQX10805 had rolled onto its side about 30°, and (56) UTLX971273 had rolled onto its side about 20°. Additionally, the cars came to rest with one end of each car higher than the other. Because tank car PRDs are located at the top centerline of the car and because of the tank cars' orientations after the derailment, the PRDs most likely vented at least some liquefied lading and, to varying degrees, did not function at peak efficiency—or at all, in the case of tank car (56) UTLX971273, whose PRD did not actuate. NTSB investigators found the rubber weather cover of the PRD still in place and observed no evidence of corrosion to components within the protective housing.⁸⁸ Because of the angle at which tank car (56) UTLX971273 came to rest, its PRD was in contact with liquefied anhydrous ammonia. In previous research, the FRA has noted that in many overturned tank car cases, the requirement to limit tank pressure to the PRD flow rating pressure would necessitate a larger-flow-capacity PRD (FRA 2003). Because the PRD on tank car (56) UTLX971273 failed to open altogether, it is less clear whether a PRD with increased flow capacity but without a lower start-to-discharge pressure setting could have prevented its thermal tear. The investigation could not determine why the PRD on tank car (56) UTLX971273 did not actuate.

Postaccident PRD testing found a range of start-to-discharge pressures for the devices. Tank car (55) TILX501050's PRD actuated at 266.4 psig, 5% below the rated start-to-discharge value, and the PRDs recovered from the other two thermally

⁸⁸ When mixed with moisture in the air, anhydrous ammonia becomes strongly corrosive to many metals.

breached anhydrous ammonia tank cars ((56) UTLX971273 and (59) SHQX10805) actuated at more than 315 psig—12% above the rated start-to-discharge pressure. Although a PRD that has actuated and experienced fire conditions would not likely continue to operate at its specified pressure, fire exposure would likely cause PRD springs to weaken and the start-to-discharge pressure to decrease—not increase.⁸⁹ In this accident, the marginally higher start-to-discharge pressures for tank cars (56) UTLX971273 and (59) SHQX10805 may be related to heat-damaged poppet seat discs, which were indented and likely stuck to the valve. Repeated testing of each PRD found a downward trend of start-to-discharge pressures, further suggesting this explanation.⁹⁰

The postaccident examinations also confirmed that the PRD valves were not stuck shut, the discharge ports were not blocked or chemically degraded, and the devices had functioned as designed to relieve pressure. Although the start-to-discharge pressure is an important PRD parameter for establishing the point at which the tank responds to an internal pressure increase, FRA research has found the start-to-discharge pressure of a PRD used to transport liquid PIH materials is not the most significant factor in the pool fire survival of the tank car, provided a large enough flow capacity is chosen for the valve (FRA 2003). Thus, the NTSB concludes that although the start-to-discharge pressures of the PRDs on tank cars (56) UTLX971273 and (59) SHQX10805 were above their design pressures, these were likely not as large a factor in the formation of thermal tears in the tank shells as the insufficient flow capacity of the devices.

The postaccident examinations of the PRDs on tank cars (55) TILX501050 and (59) SHQX10805 found evidence that these devices had actuated at some point during the pool fire. The PRD poppet weather covers were missing on these two cars; if present before the derailment, these covers would have been blown off by the actuating PRDs. NTSB investigators found further evidence that the two PRDs had actuated; heavy corrosion was observed on the valve handwheels and internal surfaces of the protective housing covers, indicating contact with corrosive ammonia.

The volumetric flow rate for liquid discharge is less than that of vapor at any given pressure—that is, vapor will vent through a PRD at a higher rate than liquid. Because of this, very high pressures may develop in pool fire scenarios if the flow

⁸⁹ The FRA considers such a reduction in venting pressure to be safe given the high probability of weakened tank car steel in fire exposure conditions (FRA 2022).

⁹⁰ Also, if the properties of poppet seat discs changed because of the heat damage, the tested start-to-discharge pressures may not have been truly representative of the actuation pressures experienced *in situ* during the pool fire.

capacity of the PRD is small and the rate of thermally induced product expansion is large, if the PRD is unable to pass liquid product at a sufficient rate, or both (FRA 1984). The flow (surface) area of the PRDs was about 0.809 square inches. The length of the thermal tears ranged from about 4.25 inches to 8.5 inches, with an average width of about one-quarter inch. Therefore, the surface area of the thermal tear breaches ranged from about 1 to 2 square inches—up to twice the flow capacity provided by a functioning PRD and an indication of the need for greater flow capacity than was made available by the tank cars' PRDs. Therefore, the NTSB concludes that the shells of anhydrous ammonia tank cars (55) TILX501050 and (59) SHQX10805 developed thermal tears because the rate at which their PRDs vented material was insufficient to offset the internal pressure rise caused by increased temperatures from pool fire exposure.

The relatively small size of the thermal tears found in this accident is likely related to DOT-112 tank car design improvements: thicker tank shells, material constructed of normalized steel for greater fracture toughness, and thermal protection systems to reduce the rate of heat transfer and of tank pressure increase from pool fire exposure.⁹¹ Nevertheless, in this accident, the formation of the thermal tears negated the safety benefit of another safety feature of DOT-112 tank cars—the reclosing PRD. Anhydrous ammonia vented continuously through the thermal tears, overtaking the pressure relief function of the PRDs, and resulting in the release of the entire contents of each of the three tank cars.

Based on their orientations in the pileup, the PRDs of tank cars (55) TILX501050 and (59) SHQX10805 actuated in vapor space and in upper liquid space. Yet in both cases, the tank cars sustained nearly identical thermal tear damage from overpressure conditions in combination with high shell temperatures. This evidence suggests that the PRDs on these tank cars, whether functioning as designed or not, made no difference in the tank cars' ability to survive the pool fire because the flow capacity of the PRD itself was inadequate. The NTSB concludes that greater PRD flow capacity would have improved the ability of anhydrous ammonia tank cars (55) TILX501050 and (59) SHQX10805 to survive the pool fire with a reduced chance of thermal breaching damage.

The PRD selection criteria formula provided in Appendix A of the AAR's *Specifications for Tank Cars* is used to estimate the required flow capacity of the

⁹¹ Historically, thermal tears have been associated with large shell breaches. The most severe of these incidents, such as the derailment and subsequent release of hazardous materials and fire in Casselton, North Dakota, in 2014, have been associated with less-robust tank cars with thinner tank shells or with tanks lacking thermal protection systems (NTSB 2017a).

device (AAR 2024).⁹² The formula accounts for the physical properties of the gas lading and the thermal conductance of the tank's insulating material. According to the formula, a tank car with more insulation has a lower required PRD flow capacity.

The builders of the thermally breached tank cars used the AAR formula to derive PRD minimum flow capacity requirements, which ranged from 1,340 SCFM to 2,769 SCFM. The flow capacity of the Rego PRD used on all three cars was 3,549 SCFM, well above the minimum flow capacity required for the cars' PRDs. NBBI testing indicated that the flow capacities of each of the PRDs on the thermally breached tank cars also exceeded the requirements. Although the worst-case test on the PRD for tank car (55) TILX501050 showed a flow capacity of about 5% below the valve rating, this was still more than twice what TrinityRail's calculations required. Nonetheless, these are exceedingly low flow capacities compared to those of PRDs used for other non-PIH commodities (for example, flammable liquids and gases), which can be up to 10 times greater. This discrepancy relates to the AAR formula in that if a tank car has greater thermal protection, then its PRD flow capacity may be reduced—such as for the thermally protected DOT-112 tank cars involved in this derailment. This reduces the required flow capacity from as much as 35,000 to 3,500 SCFM.⁹³

In this accident, negative consequences to the community were avoided because of the derailment's remote location along with environmental factors reducing lethality of the highly poisonous anhydrous ammonia vapor plume by dispersal or consumption (wet weather, strong winds, and the pool fire itself). On September 29, 2023, in Teutopolis, Illinois, a combination truck tractor and cargo tank carrying about 7,600 gallons of anhydrous ammonia departed the roadway and struck a parked utility trailer, puncturing the cargo tank head and causing a release of poisonous anhydrous ammonia vapor (NTSB 2025b). Although the cargo tank was carrying far less material than was released in Bordulac, exposure to anhydrous ammonia vapor killed five people and injured 13 others.

Given the great risk of death and injury posed by uncontrolled releases of PIH materials, it is concerning that a thermal breach of a PIH tank car occurred at all—

⁹² The equation used for insulated or thermally protected tank cars is $Q_a = 2G_i \times U \times A^{0.82}$ where Q_a is the minimum rate of discharge (SCFM); G_i is 2.726, the anhydrous ammonia gas factor for insulated containers; U is the overall thermal conductance of the insulating material at 100°F (Btu/h-ft²-°F); and A is the total outside surface area of the tank (ft²).

⁹³ Non-thermally protected tank cars are not an option for the transportation of anhydrous ammonia.

particularly in a tank car of a design developed specifically to prevent such releases. The NTSB therefore recommends that AAR revise the formula for required PRD flow capacity specified in Appendix A of its *Specifications for Tank Cars* and the requirements for PRDs and thermal protection systems to ensure the survivability of tank cars carrying PIH materials in engulfing pool fire conditions.

Although the current PRD flow capacity selection criteria help limit the quantity of PIH material released during an incident, the currently authorized PRD flow capacity for anhydrous ammonia and other PIH materials in fully engulfing pool fire conditions needs to be further investigated. The NTSB therefore concludes that adjusting PRD parameters to provide a better balance between the physical characteristics of the lading and the need to vent highly toxic material can limit the potential for thermal tears in an incident scenario. This can be achieved by varying the flow capacity and start-to-discharge setting of the selected PRD. In 2015, the AAR summarized this issue by noting that an appropriately sized PRD means “sizing the device in conjunction with the tank car’s thermal protection system to allow the release of only enough commodity to protect against thermal tear” (Kirmayer 2015). PHMSA enforces standards related to thermal protection system performance for tank cars and conducts research and publishes guidance for regulated entities and the public. Therefore, the NTSB recommends that PHMSA issue guidance for the selection of an optimal PRD based on the characteristics of the PIH material transported in a tank car.

2.4.2 Thermal Protection Standards

To meet the 100/30-minute survivability benchmark, thermal protection systems for pressure tank cars include a jacket and thermal protection blanket along with the PRD. If a tank car exposed to an engulfing fire has thermal protection defects, its insulating ability is compromised and internal temperature—and therefore pressure—increases, and the PRD actuates. Then the liquid levels drop rapidly, increasing the vapor space in the tank and causing failure to occur more quickly (Birk 2005).⁹⁴

When exposed to pool fire conditions, AAR TC-128 steel typically fails in one of two ways: short-term overheating, characterized by knife-edge wall thinning, or high-temperature creep, characterized by thick edges and a rough appearance from the linkage of micro-voids (Simha 2016). The appearance of the shell material

⁹⁴ In this case, the low lading level found in the thermally breached tank cars after the accident was due to uncontrolled continuous releases caused by the thermal tears themselves.

surrounding the tears on the three tank cars indicated temperature exposures of more than 600°F and were characteristic of high-temperature creep.⁹⁵ In postaccident examinations, the NTSB found no evidence of gaps or voids in the thermal protection blanket or jacket material near the thermal tears on tank cars (55) TILX501050 and (56) UTLX971273. Impact damage had torn the jacket and ceramic fiber blanket of tank car (59) SHQX10805, leaving a large gap in thermal protection in the region where the thermal tear developed. It is likely that, because this gap left part of the tank car in a non-thermally protected condition, the thermal tear on (59) SHQX10805 occurred relatively soon after the derailment.

All tank cars that require thermal protection systems are subject to the same performance standard, regardless of the commodity carried. Federal regulations and industry requirements designate PIH as a special category of hazardous material because of the extreme danger that even low concentrations of these materials may pose to human health and the environment. Therefore, PIH materials such as anhydrous ammonia are now transported in more structurally robust, higher-test pressure tank cars—but the thermal protection standards for these tank cars are no more protective than those for tank cars carrying non-PIH materials.⁹⁶ Under current federal regulations, it is acceptable for a PIH tank car to be designed to fail and release its entire contents after 100 minutes of exposure to a pool fire.

Notably, AFFTAC modeling for tank car (59) SHQX10805 predicted the tank would fail after 144 minutes of pool fire exposure under certain conditions. Any amount of PIH material release—and certainly an uncontrolled release—is likely to cause serious injuries. As mentioned earlier, the remote location and various environmental factors in this accident averted injuries and loss of life like those that have occurred in the Teutopolis, Minot, and Graniteville accidents.

The FRA notes that optimally designed thermal protection systems may differ among various materials because of the varying characteristics of different chemicals (2003). The 100/30-minute survivability standard was developed based on estimates of the time required for emergency responders to safely evacuate the surrounding

⁹⁵ Until the ruptures occurred, the extra thickness of the tank shell material along with their mostly wetted interior surfaces probably provided some longevity independent of the function of the thermal protection system.

⁹⁶ As of the fourth quarter 2024, there were about 1,743 HM-246-compliant tank cars in anhydrous ammonia service; the other half are noncompliant (AAR 2025a). The noncompliant portion of this fleet must be phased out of use by January 1, 2028.

area before catastrophic tank car failure (FRA 2003).⁹⁷ The Emergency Response Guidebook directs first responders to PIH rail tank car release to protect persons downwind of the spill for up to 7 miles, depending on wind conditions and the specific material (PHMSA 2024).⁹⁸

As the NTSB investigations of the Graniteville and Minot accidents revealed, an uncontrolled release of toxic gas can quickly become deadly, and the emergency response can be affected by postaccident circumstances. The Graniteville investigation found that all nine deaths occurred within minutes of the chlorine gas release. In Minot, emergency responders issued a shelter-in-place order, but because of a power outage, some residents did not receive updates on the protective action and left their homes, leading to serious injuries. Thermal protection survivability standards for PIH tank cars should therefore not be merely equivalent to tank cars carrying less-toxic flammable gases or liquids. The NTSB concludes that the potential for catastrophic effects in any release of PIH material is such that performance standards for PIH tank cars should allow for no release of these materials other than through reclosing PRDs. The NTSB further concludes that by applying the same fire survival requirements to PIH tank cars as to those containing materials that are less hazardous, the thermal protection system performance criteria of 49 *CFR* 179.18 do not adequately consider the different physical characteristics and toxicological effects of all potential releases of a PIH material into a community.

In its 2003 report on tank car relief valve requirements, the FRA recommended the need for a more rational basis to determine how long a tank car carrying PIH materials must survive a fire. The report also noted that plume modeling can help determine the likely worst-case scenarios for downwind exposures and the results used in conjunction with evacuation protocols to develop realistic estimates for safe evacuation timing. To date, however, no follow-up action has been taken to investigate or implement enhanced thermal protection and pressure relief valve requirements for fire survival time.

The reduction in release probability of HM-246-compliant next-generation tank cars such as the DOT-112 over earlier designs is mainly derived from improved puncture resistance rather than from an improved ability to withstand thermal exposure. As noted earlier, the anhydrous ammonia releases from the DOT-112 tank

⁹⁷ Also see 60 FR 49048.

⁹⁸ The Emergency Response Guidebook defines protective actions as the steps taken to preserve the health and safety of emergency responders and the public during an incident involving hazmat releases. These can include evacuation, shelter-in-place, or a combination of the two actions.

cars were not due to mechanical damage but to the low flow capacity of the PRDs, which resulted in inadequate thermal resilience. Therefore, the NTSB recommends that PHMSA develop and implement new thermal performance criteria for tank cars carrying liquefied gases classified as PIH materials that allow for no release of the tank car's lading during a fully engulfing pool fire except through reclosing PRDs.

2.5 Thermal Damage Vulnerability of DOT-117R Gaskets

The tank structure of tank car (60) CTCX300362 sustained considerable mechanical damage. The tank car came to rest upright in the pileup and NTSB investigators found that more than half the tank's surface had been exposed to the pool fire. The 20-inch-diameter gasket in the manway cover groove was destroyed in the fire, having been reduced to carbon fragments. The maximum service temperature of the EPDM synthetic rubber used in the manway gaskets is about 300°F, but the scorched paint and red oxidation discoloration of the tank jacket steel near the manway indicated that the manway was likely subjected to temperatures well over 600°F from the pool fire. With the manway gasket burned out, the loss of seal created a leak pathway and the release of about half of the tank car's methanol lading. Therefore, the NTSB concludes that the vulnerability of the gasket material used to seal the manway of DOT-117R tank cars to thermal damage elevates the risk of a hazardous materials release through this pathway.

A recent investigation into a 2022 derailment of a BNSF Railway ethanol unit train in Oklaunion, Texas, found a similar lack of heat-resistant gasket materials in DOT-117 tank cars carrying flammable liquids (NTSB 2023). In that accident, multiple manway gasket failures led to massive releases of flammable liquid and cascading fire damage. We found that using gaskets with higher service and survival temperatures would likely increase the fire exposure survival time of DOT-117 tank car service equipment in flammable liquid service and reduce the severity of hazardous materials releases. We therefore recommended that the FRA and PHMSA work together to:

Develop and publish benchmark service and survival temperatures for gaskets to be used in tank cars used in flammable liquid service that reflect currently available gasket materials. (R-23-12, R-23-14)⁹⁹

⁹⁹ Safety Recommendations R-23-12 and R-23-14 are classified Open–Initial Response Received.

An assessment of the availability of gaskets, their compatibility with flammable liquids, and their survivability under pool and torch fire conditions facilitates the development of a benchmark service temperature. We recommended that the FRA and PHMSA again work together, once this benchmark is established, to:

Develop and publish thermal performance standards for gaskets used in tank cars in flammable liquid service that address both accident and normal transportation conditions. (R-23-13, R-23-15)¹⁰⁰

On January 5, 2024, FRA and PHMSA broadly outlined a plan to review previous gasket research and performance data to conduct a gap analysis to provide publicly available benchmark gasket service and survivability standards. The agencies stated that they also planned to develop new thermal performance standards that will address accident scenarios for gaskets used in tank cars operating in flammable liquid service, with PHMSA to issue new rules incorporating the new thermal performance standards. In January 2026, PHMSA noted it had commissioned a report reviewing existing studies and offering near- and long-term solutions for improving service equipment performance in fire conditions (Dalske et al. 2025). PHMSA also stated that the FRA would lead further research and development of DOT-117 tank car thermal protection standards. Therefore, the NTSB reiterates Safety Recommendations R-23-12, R-23-13, R-23-14, and R-23-15 to the FRA and PHMSA and classifies them Open–Acceptable Response.

2.6 Hazards in Tank Car Placement

The probability and outcome of a derailment are affected not only by tank car equipment crashworthiness as discussed above, but also the in-train placement of hazmat railcars.¹⁰¹ This includes the arrangement of tank cars transporting hazardous materials in relation to buffer railcars and in relation to each other, as well as their placement within a train, where certain locations can increase the probability of derailment or where in-train forces may create a greater risk of breaching damage.¹⁰²

¹⁰⁰ Safety Recommendations R-23-13 and R-23-15 are classified Open–Initial Response Received.

¹⁰¹ For more information on the evolution of regulations related to PIH classification and to tank car placement, see the addendum report in the [public docket](#) for this investigation.

¹⁰² *Buffer railcars* are non-placarded railcars that are used to separate locomotives from hazardous materials tank cars.

In this accident, the hazardous conditions typically present in a derailment were compounded by the placement of general-service tank cars carrying about 164,000 gallons of flammable liquid methanol both immediately in front of and immediately behind several anhydrous ammonia tank cars. (See figure 30.) The in-train placement of the methanol and anhydrous ammonia tank cars provided a scenario in which the anhydrous ammonia tank cars were run into from behind by the less-crashworthy DOT-117R flammable liquids tank cars. This scenario ultimately led to the DOT-112 tank cars being engulfed in a pool fire, resulting in the thermal tears discussed in section 2.4. Without the methanol-fueled pool fire, about 90,000 gallons of anhydrous ammonia would not have been released from the three tank cars that experienced thermal tears.

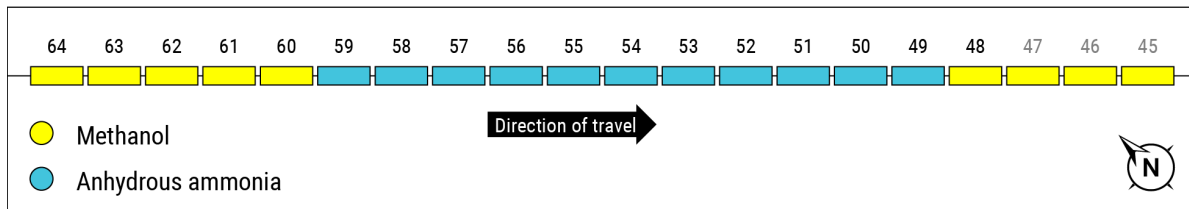


Figure 30. Arrangement of hazmat tank cars line 45 through 64 on train 242-03.

Our investigation of the Graniteville accident found that even the strongest tank cars in service can be punctured in accidents involving trains operating at moderate speeds. We recommended that the FRA:

Require railroads to implement operating measures, such as positioning tank cars toward the rear of trains and reducing speeds through populated areas, to minimize impact forces from accidents and reduce the vulnerability of tank cars transporting chlorine, anhydrous ammonia, and other liquefied gases designated as poisonous by inhalation. (R-05-16)

We reiterated recommendation R-05-16 in 2006, after an accident in Macdona, Texas, in which a train collision resulted in a chlorine gas release and the deaths of three people. In 2009, the FRA issued a regulation that imposed a 50-mph speed limit on all loaded railroad tank cars transporting PIH materials. The same year, the FRA stated in its response to recommendation R-05-16 that a mandate for such operational requirements could not be accomplished without introducing additional safety risks from increased switching operations, along with imposing extreme economic burden on the industry (Szabo 2009). In an earlier report, the FRA had stated that it saw “no merit in disturbing established and very effective requirements already embodied” in the HMR and added that the advantages of refinements to train placement requirements would not offset the costs, in particular the safety risks associated with the additional switching of cars (FRA 2005). The FRA also cautioned

that mandating preferred placement could lead to unsafe train handling because of in-train forces that can be exacerbated by the relative placement of heavier or lighter railcars, and ultimately cited the 2009 regulation as justification for their response to recommendation R-05-16.

In a 2008 letter commenting on the 50-mph speed limit rule, we stated that the regulation did not include operating measures to minimize impact forces from accidents or to reduce the vulnerability of tank cars transporting PIH materials. We expressed our disappointment that the FRA had pursued neither the placement of tank cars in trains nor speed restrictions and had not suggested positive alternatives. Based on the FRA's response, the NTSB classified recommendation R-05-16 Closed–Unacceptable Action on August 2010.

Transport Canada's hazardous materials transportation regulations require physical separation between certain hazardous materials ("dangerous goods" in Canadian regulatory language) unless doing so is likely to have a negative safety impact on train dynamics.¹⁰³ Still, Canadian regulations do not require separation of all PIH materials, including anhydrous ammonia, from Class 3 flammable liquids—like methanol—or Division 2.1 flammable gases.

The interactions between adjacent commodities are a crucial concern, as chemical incompatibility can lead to toxic chemical releases, fires, or explosions. Current federal regulations outlined in 49 *CFR* Part 174 Subpart D require that railcars carrying explosives and those carrying some poisonous gases are not coupled together, but Class 2 compressed gases (including many PIH materials) may be placed next to Class 3 flammable liquids. Thus, neither CPKC's rules nor federal regulations prohibit a train from transporting methanol and anhydrous ammonia tank cars next to each other, as they were in train 242-03.

In the derailment, the breach of one type of tank car affected the survivability of another, and cascading damage from flammable liquids led to the failure of intact, more-robust tank cars carrying PIH materials. Tank cars retrofitted from older DOT-111 designs have the poorest crashworthiness of the DOT-117R fleet in terms of likelihood of release in a derailment scenario (Treichel et al 2019). The DOT-117R100W tank cars involved in this derailment—methanol tank cars (63) CTCX300358 and (64) CTCX732476, discussed in this section, and (60) CTCX300362, discussed in section 2.5—were derived from legacy-class DOT-111 tank cars, with the thinnest authorized head and shell of 0.4375-inch thick, non-normalized ASTM

¹⁰³ See Transport Canada, Transportation of Dangerous Goods Regulations (SOR/2001-286), Part 10.6(1).

A516-70 steel with less-than-optimum fracture toughness. The severity of the shell failures in tank cars (63) CTCX300358 and (64) CTCX732476 were a result of the tank cars being constructed with relatively thin, non-normalized, lower-quality steel, which has a lesser capacity to resist low-energy fracture propagation than other car types. The observed damages to the DOT-117R retrofitted tank cars were reminiscent of the derailment damage performance of many legacy DOT-111 tank cars, particularly those involved in the 2013 derailment of a Montreal, Maine & Atlantic freight train in Lac-Mégantic, Quebec, Canada, which led to the rapid release of 6 million liters of crude oil and a pool fire that killed 47 people (TSB 2014). The NTSB concludes that the allowance to retrofit such DOT-111 tank cars for continued use in flammable liquids service has not resulted in the same safety improvements as newly built DOT-117 tank cars.

Recognizing this issue with trains comprised of mixed specification tank cars having widely varying crashworthiness, the NTSB has previously sought to encourage railroads and shippers to assemble trains in a more strategic manner that minimizes the risk of hazardous materials releases from more vulnerable tank cars. Following investigations of the April 24, 2019, derailment of a Union Pacific Railroad ethanol unit train in Fort Worth, Texas, and the February 13, 2020, derailment of an ethanol unit train in Draffin, Kentucky, we published a report on the placement of DOT-111 tank cars in high hazard flammable trains, which found the severity of these accidents could have been mitigated by placing more vulnerable tank cars in locations within the train where they are less likely to derail or to sustain accident damage (NTSB 2020).¹⁰⁴ Thus, the NTSB issued the following safety recommendation to the AAR, the ASLRRA, and the Renewable Fuels Association, calling for them to:

Develop and adopt guidelines and recommended practices for the systematic placement of the most vulnerable tank cars in high hazard flammable trains, such as unmodified US Department of Transportation-111 tank cars, in positions of trains where they are least likely to derail or to sustain mechanical damage from the effects of trailing tonnage or collision in an accident.
(R-20-27)¹⁰⁵

¹⁰⁴ Federal regulations at 49 *CFR* 171.8 define a *high hazard flammable train* as a single train transporting 20 or more loaded tank cars of a Class 3 flammable liquid in a continuous block or one transporting 35 or more such tank cars throughout the train consist. Therefore, CPKC train 242-03 was not a high hazard flammable train.

¹⁰⁵ The overall classification of NTSB safety recommendation R-20-27 is Open–Acceptable Response.

Soon after the recommendation was issued, the ASLRRA and the Renewable Fuels Association developed best practices for the rail transport of ethanol and promoted them to industry, and the NTSB classified the recommendation Closed–Acceptable Action on June 15, 2022.

The AAR's response to the recommendation, however, is currently classified Open–Unacceptable Response. In correspondence with the NTSB dated December 28, 2021, the AAR stated it did not consider it necessary to expend time and money to develop the recommended guidance because the risk associated with DOT-111 tank cars transporting ethanol would be eliminated as of the phase-out date of April 2023. In our response, we pointed out the substantial work completed by the FRA and its Rail Safety Advisory Committee on positioning DOT-111 tank cars and reaffirmed that industry guidelines and recommended practices are effective ways for shippers and carriers of high hazard flammable materials to achieve the safety benefits of fewer breached tank cars in derailments. Further, although the phaseout of DOT-111 tank cars for the transportation of ethanol occurred as scheduled, the intent of recommendation R-20-27 was not limited to transporting ethanol in DOT-111 tank cars; the intent was to place the most vulnerable tank cars in high hazard flammable trains in the safest positions in the consist. For example, research indicates the probability of release occurring in a mainline accident for these retrofitted DOT-117R tank cars is about three times greater than for tank cars constructed to DOT-117J100W specifications (Treichel et al 2019). The NTSB concludes that industry-recommended practices and federal train placement requirements of 49 *CFR* Part 174 Subpart D do not sufficiently protect from harmful interactions that can occur between adjacent tank cars carrying PIH materials, including anhydrous ammonia, and flammable liquids in a derailment scenario. We therefore recommend that PHMSA, in coordination with the AAR, identify the appropriate amount of separation between tank cars transporting PIH materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of PIH tank cars being exposed to pool fire conditions. We further recommend that the AAR support PHMSA in identifying the appropriate amount of separation between tank cars transporting PIH materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of PIH tank cars being exposed to pool fire conditions.

PHMSA has required physical separation between different types of hazmat classes before. In 2016, after the 2011 crash of Asiana Flight 991 on Jeju Island, Korea, we recommended PHMSA require physical separation between Class 9 lithium batteries and Class 3 flammable liquids when stowed onboard an aircraft. The agency

established such requirements in the HMR in 2020.¹⁰⁶ The NTSB therefore recommends that PHMSA, using the results of the determination described in R-26-3, reduce the vulnerability of tank cars transporting liquefied gases designated as poisonous by inhalation, including anhydrous ammonia, by requiring their physical separation from flammable hazardous materials when placed in a train.

The NTSB recognizes that railroads must weigh the ideal lowest risk placement of cars carrying hazardous materials in a train against the safety risk involved in moving and switching railcars to achieve that ideal placement, but industrywide guidance can help railroads align their position-in-train rules. Therefore, the NTSB recommends that the AAR, using the results of the determination described in R-26-3, modify train placement instructions contained in its *United States Hazardous Materials Instructions for Rail* to ensure that tank cars transporting PIH materials, including anhydrous ammonia, are physically separated from flammable hazardous materials.

2.7 Continued Use of DOT-111s

The methanol release from tank car (62) MFCX132265 contributed to the pool fire that affected the anhydrous ammonia tank cars discussed in section 2.4. The NTSB investigation found that the half-height head shield that had been attached to its B end had separated and was missing from (62) MFCX132265. The location of the puncture on the B-end tank head indicated that the head shield would have protected the tank car from puncture had it been present. On the tank car's A end, the head was punctured above the half-height head shield.

Tank car (62) MFCX132265 was a DOT-111 specification CPC-1232 tank car. Other NTSB accident investigations have identified half-height head shield separation involving unjacketed CPC-1232 tank cars. A 2015 derailment in Heimdal, North Dakota, involved six CPC-1232 specification DOT-111 tank cars with half-height head shields, and of these, two experienced separation of their head shields (NTSB 2017b). The NTSB also notes anecdotal accounts from FRA hazmat inspectors of loosening mounting bolts and of half-height head shields falling off tank cars, not only in derailments, but also during normal transportation.

Even without a record of separating and falling off, the design of the half-height shields leaves half the tank head unprotected; this vulnerability to puncture of the upper head sections of unjacketed CPC-1232 tank cars is well known.

¹⁰⁶ Safety Recommendation A-16-1 was classified Closed–Acceptable Action on December 10, 2020.

In its investigation report on the Lac-Mégantic accident, the Transportation Safety Board of Canada noted that all but four of the 63 derailed DOT-111 specification tank cars exhibited some form of impact damage in the top portion of at least one head, and that a full head shield on the tank cars that derailed “would have been beneficial” (TSB 2014). (See figure 31 for examples of half- and full-height head shields.)



Figure 31. An example of a half-height head shield (*left*) and a full-height head shield (*right*), which is typically built into the tank shell. (Source: AAR.)

In addition to the two head punctures on tank car (62) MFCX132265, which were severe enough on their own that they emptied the tank, the protective housing on the tank car’s top fittings separated and sheared away the PRD and the liquid and vapor valves, creating additional leak pathways. The angle at which the tank car came to rest allowed the pressure plate holes created by the missing fittings to drain a significant amount of methanol; therefore, even without the head punctures, (62) MFCX132265 would have released lading.¹⁰⁷

In 2015, PHMSA and FRA adopted specifications for new and retrofitted DOT-117 flammable liquids tank cars that included full-height head shields meeting the requirements of 49 CFR 179.16(c).¹⁰⁸ Under 49 CFR 173.242, however, DOT-111 tank cars built to the CPC-1232 standard are authorized for continued transportation of flammable liquids in Packing Group II and III, other than crude oil or ethanol, until May 1, 2029. Although the breached tank car (62) MFCX132265 was not the only

¹⁰⁷ Although the top fittings rollover protection for CPC-1232 specification DOT-111 tank cars is less robust than that required for DOT-117 tank cars, the amount of impact force that separated the protective housing and damaged the top fittings may have led to the same outcome in either case.

¹⁰⁸ 80 FR 26749, May 8, 2015.

source of flammable material released following the derailment in this accident, of all the tank cars involved in this derailment, the CPC-1232 specification DOT-111 tank car was the most likely to release hazardous materials. The documented postaccident damage also indicated multiple release pathways from tank car (62) MFCX132265. Therefore, the NTSB concludes that the vulnerability to mechanical breaches of CPC-1232 specification DOT-111 tank cars with half-height head shields resulted in the release of flammable liquid from methanol tank car (62) MFCX132265, which contributed to the thermal damage and release of anhydrous ammonia from other, more-robust DOT-112 tank cars.

In our investigation of the Norfolk Southern Railway derailment and hazardous materials release in East Palestine, Ohio, in February 2023, the postaccident examination of mechanically breached DOT-111 tank cars revealed that five of them had sustained cracks or punctures in the tank heads. We found that the presence of DOT-111 tank cars carrying hazardous materials in a mixed-freight train can increase the risk of more resilient tank cars releasing hazardous materials following a derailment (NTSB 2024). We also found that although it is feasible for the railroad industry to voluntarily accelerate the phase-out of the remaining DOT-111 tank cars in flammable liquids service, economic and business disincentives make this unlikely. Therefore, the NTSB recommended that PHMSA:

Obtain the necessary legislative authority and accelerate the deadline for removing specification DOT-111 tank cars from flammable liquids service. (R-24-12)¹⁰⁹

The NTSB further recommended that PHMSA:

Establish a tank car replacement schedule whereby non-pressure tank cars in any hazardous materials service must meet or exceed the safety standards of the DOT-117 specification; if necessary, obtain legislative authority to act on this recommendation. (R-24-13)¹¹⁰

In February 2023, the US Secretary of Transportation called on Congress to revise the phaseout deadline. On October 11, 2024, PHMSA stated that it concurred with the recommendation to accelerate the phase-out of DOT-111 tank cars, and that as a first step, it was conducting a risk-based analysis to determine the economic effects and safety impacts of different approaches to replacing non-pressure tank cars

¹⁰⁹ Safety Recommendation R-24-12 is classified Open—Initial Response Received.

¹¹⁰ Safety Recommendation R-24-13 is classified Open—Initial Response Received.

in any hazardous materials service with those that meet or exceed the safety standards of the DOT-117 specification.

PHMSA also stated that it concurred with the recommendation to mandate the use of tank cars meeting or exceeding DOT-117 standards, but that changing the mandate would require legislative action. The agency stated it is providing Congress with technical assistance with legislation to revise the phaseout deadline and is prepared to support any relevant changes to the legislation. Figure 32 shows the composition of the nation's rail tank car fleet through 2024.

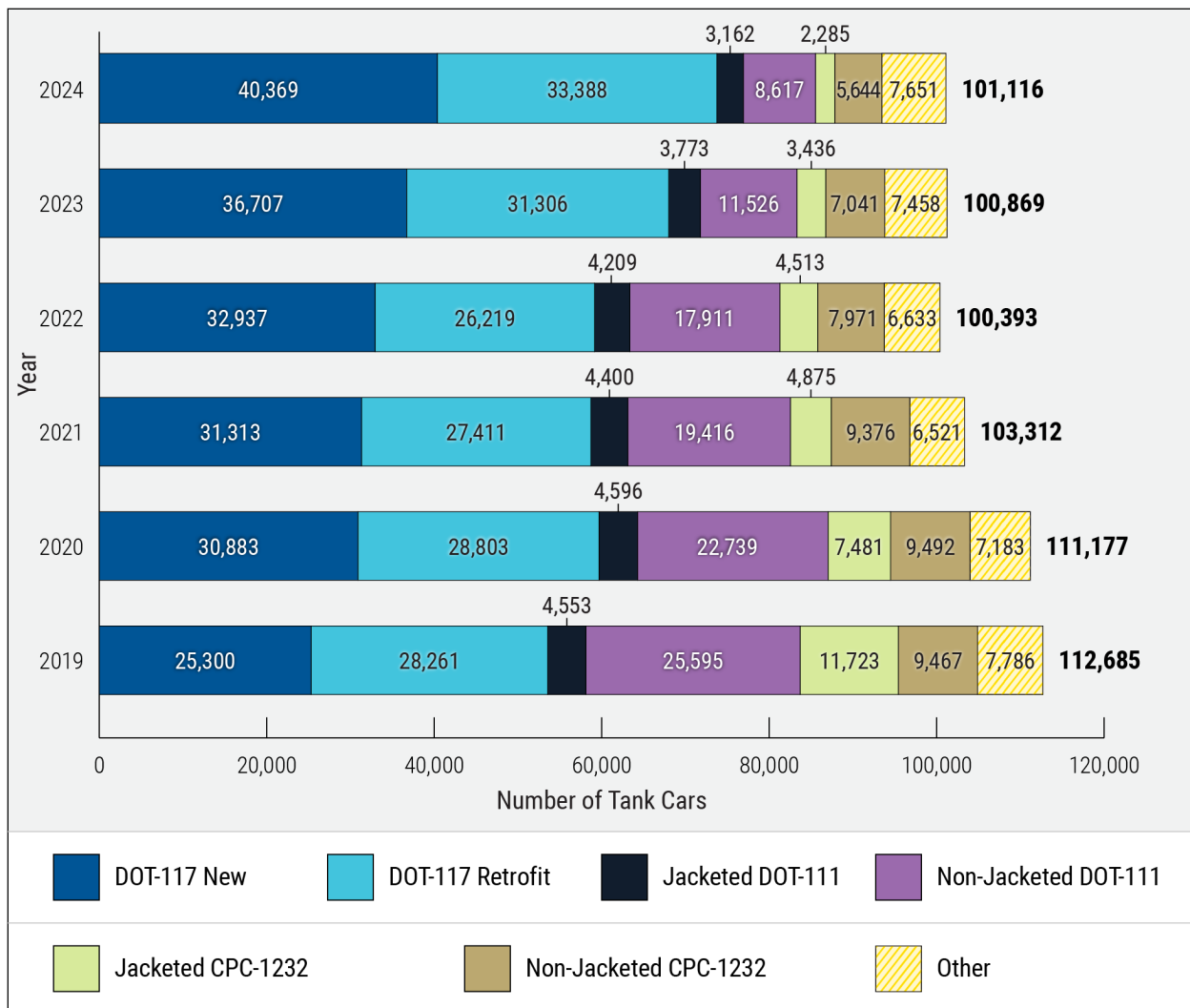


Figure 32. Fleet composition of rail tank cars carrying class 3 flammable liquids, 2019-2024. (Source: Bureau of Transportation Statistics.)

As this incident shows, the risk of DOT-111 tank cars contributing to the severity of accidents remains significant. These tank cars are more vulnerable to

mechanical breaching than other tank cars during a derailment and should be removed from flammable liquids service as soon as possible. The AAR reported that in 2024, 11,625 CPC-1232 specification and 13,553 DOT-111 tank cars were still in use transporting flammable liquids (AAR 2025b).

The NTSB acknowledges PHMSA's efforts to provide technical assistance to Congress and advocating for appropriate legislation. The continued use of these unsafe tank cars, which once again contributed to the release of PIH materials from other, more structurally sound tank cars in the pileup, warrants reiteration of the relevant recommendations from East Palestine. Therefore, the NTSB reiterates Safety Recommendations R-24-12 and R-24-13 to PHMSA and classifies them Open–Acceptable Response pending the required legislation.

3 Conclusions

3.1 Findings

1. None of the following issues caused or contributed to the accident: (1) weather and visibility; (2) track washout; (3) train 242-03 crew training and qualifications, toxicology, or performance; (4) mechanical condition of train 242-03; (5) signals and train control; (6) tank car loading and securement; (7) mechanical damage resistance of DOT-112 tank cars; or (8) evacuation actions.
2. The sudden collapse of the void in the subgrade supporting the track at milepost 343.4 initiated a dip in the rails, and as the 39th and 40th railcars traversed the dip, the applied forces from train 242-03 likely caused the south rail to break.
3. The 48th through 76th railcars on train 242-03 derailed because the train traversed a broken rail with no track bed support.
4. The five breached methanol tank cars supplied fuel for a fully engulfing pool fire that led to thermal breaching of three of the adjacent anhydrous ammonia tank cars.
5. Although the frequency of culvert inspections was sufficient to detect adverse conditions, Canadian Pacific Kansas City Railroad's method of culvert inspection—observing the culverts from their ends—did not allow inspectors to fully assess or quantify the condition of the culverts because of the narrow and limited viewing angle.
6. Because Canadian Pacific Kansas City Railroad's culvert inspection program did not offer substantive guidance to inspectors on how to rate specific conditions, the east and west culverts' ratings did not reflect the serious conditions—a complete blockage with separations in one and culvert separations and soil infiltration in the other—that should have required appropriate and timely remedial action.
7. Although the start-to-discharge pressures of the pressure relief devices on tank cars (56) UTLX971273 and (59) SHQX10805 were above their design pressures, these were likely not as large a factor in the formation of thermal tears in the tank shells as the insufficient flow capacity of the devices.
8. The shells of anhydrous ammonia tank cars (55) TILX501050 and (59) SHQX10805 developed thermal tears because the rate at which their pressure relief devices vented material was insufficient to offset the internal pressure rise caused by increased temperatures from pool fire exposure.

9. Greater pressure relief device flow capacity would have improved the ability of anhydrous ammonia tank cars (55) TILX501050 and (59) SHQX10805 to survive the pool fire with a reduced chance of thermal breaching damage.
10. Adjusting pressure relief device parameters to provide a better balance between the physical characteristics of the lading and the need to vent highly toxic material can limit the potential for thermal tears in an incident scenario.
11. The potential for catastrophic effects in any release of poison inhalation hazard material is such that performance standards for poison inhalation hazard tank cars should allow for no release of these materials other than through reclosing pressure relief devices.
12. By applying the same fire survival requirements to poison inhalation hazard tank cars as to those containing materials that are less hazardous, the thermal protection system performance criteria of Title 49 *Code of Federal Regulations* 179.18 do not adequately consider the different physical characteristics and toxicological effects of all potential releases of a poison inhalation hazard material into a community.
13. The vulnerability of the gasket material used to seal the manway of DOT-117R tank cars to thermal damage elevates the risk of a hazardous materials release through this pathway.
14. The allowance to retrofit such DOT-111 tank cars for continued use in flammable liquids service has not resulted in the same safety improvements as newly built DOT-117 tank cars.
15. Industry-recommended practices and federal train placement requirements of Title 49 *Code of Federal Regulations* Part 174 Subpart D do not sufficiently protect from harmful interactions that can occur between adjacent tank cars carrying poison inhalation hazard materials, including anhydrous ammonia, and flammable liquids in a derailment scenario.
16. The vulnerability to mechanical breaches of CPC-1232 specification DOT-111 tank cars with half-height head shields resulted in the release of flammable liquid from methanol tank car (62) MFCX132265, which contributed to the thermal damage and release of anhydrous ammonia from other, more-robust DOT-112 tank cars.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the derailment of Canadian Pacific Kansas City Railroad train 242-03 was the collapse of the subgrade supporting the track structure. Contributing to the collapse was an erosion-caused void in the railroad subgrade created by a separation of

culvert segments at the accident location, which went undetected because of Canadian Pacific Kansas City Railroad's insufficient culvert inspection requirements. Contributing to the severity of the accident was the release of highly flammable hazardous materials caused by the breaching of five methanol tank cars, which supplied fuel for a pool fire that then led to thermal breaching of three anhydrous ammonia tank cars. Contributing to the severity of the release was inadequate thermal performance of the derailed anhydrous ammonia tank cars and the proximity of tank cars transporting highly flammable hazardous materials to tank cars carrying poison inhalation hazard materials in the train consist. Also contributing to the severity of the release was the continued use of DOT-111 and DOT-117R tank cars, which sustained considerable mechanical damage, and the use of manway gaskets that were vulnerable to thermal damage.

4 Recommendations

4.1 New Recommendations

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

To the Pipeline and Hazardous Materials Safety Administration:

Issue guidance for the selection of an optimal pressure relief device based on the characteristics of the poison inhalation hazard material transported in a tank car. (R-26-1)

Develop and implement new thermal performance criteria for tank cars carrying liquefied gases classified as poison inhalation hazard materials that allow for no release of the tank car's lading during a fully engulfing pool fire except through reclosing pressure relief devices. (R-26-2)

In coordination with the Association of American Railroads, identify the appropriate amount of separation between tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of poison inhalation hazard tank cars being exposed to pool fire conditions. (R-26-3)

Using the results of the determination described in R-26-3, reduce the vulnerability of tank cars transporting liquefied gases designated as poisonous by inhalation, including anhydrous ammonia, by requiring their physical separation from flammable hazardous materials when placed in a train. (R-26-4)

To the Association of American Railroads:

Inform your members of the circumstances of this derailment and encourage them to (1) review and revise as necessary their culvert inspection procedures to include a requirement to perform internal inspections either on foot when safe or by using technology, such as cameras or remotely operated vehicles, and (2) provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary. (R-26-5)

Revise the formula for required pressure relief device flow capacity specified in Appendix A of your *Specifications for Tank Cars* and the requirements for pressure relief devices and thermal protection systems to ensure the survivability of tank cars carrying poison inhalation hazard materials in engulfing pool fire conditions. (R-26-6)

Support the Pipeline and Hazardous Materials Safety Administration in identifying the appropriate amount of separation between tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of poison inhalation hazard tank cars being exposed to pool fire conditions. (R-26-7)

Using the results of the determination described in R-26-3, modify train placement instructions contained in your *United States Hazardous Materials Instructions for Rail* to ensure that tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, are physically separated from flammable hazardous materials. (R-26-8)

To the American Short Line and Regional Railroad Association:

Inform your members of the circumstances of this derailment and encourage them to (1) review and revise as necessary their culvert inspection procedures to include a requirement to perform internal inspections either on foot when safe or by using technology, such as cameras or remotely operated vehicles and (2) provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary. (R-26-9)

To Canadian Pacific Kansas City Limited:

Revise your culvert inspection procedures to require every culvert be inspected internally, either on foot when safe or by using technology, such as cameras or remotely operated vehicles. (R-26-10)

Revise your culvert inspection procedures to provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary. (R-26-11)

4.2 Previously Issued Recommendations Classified and Reiterated in This Report

The National Transportation Safety Board classifies and reiterates the following safety recommendations.

To the Federal Railroad Administration:

Develop and publish benchmark service and survival temperatures for gaskets to be used in tank cars used in flammable liquid service that reflect currently available gasket materials. (R-23-12)

Safety Recommendation R-23-12 is reiterated and classified Open–Acceptable Response in section 2.5 of this report.

Develop and publish thermal performance standards for gaskets used in tank cars in flammable liquid service that address both accident and normal transportation conditions. (R-23-13)

Safety Recommendation R-23-13 is reiterated and classified Open–Acceptable Response in section 2.5 of this report.

To the Pipeline and Hazardous Materials Safety Administration:

Develop and publish benchmark service and survival temperatures for gaskets to be used in tank cars used in flammable liquid service that reflect currently available gasket materials. (R-23-14)

Safety Recommendation R-23-14 is reiterated and classified Open–Acceptable Response in section 2.5 of this report.

Develop and publish thermal performance standards for gaskets used in tank cars in flammable liquid service that address both accident and normal transportation conditions. (R-23-15)

Safety Recommendation R-23-15 is reiterated and classified Open–Acceptable Response in section 2.5 of this report.

Obtain the necessary legislative authority and accelerate the deadline for removing specification DOT-111 tank cars from flammable liquids service. (R-24-12)

Safety Recommendation R-24-12 is reiterated and classified Open–Acceptable Response in section 2.7 of this report.

Establish a tank car replacement schedule whereby non-pressure tank cars in any hazardous materials service must meet or exceed the safety standards of the DOT-117 specification; if necessary, obtain legislative authority to act on this recommendation. (R-24-13)

Safety Recommendation R-24-13 is reiterated and classified Open–Acceptable Response in section 2.7 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER L. HOMENDY
Chairwoman

THOMAS CHAPMAN
Member

MICHAEL E. GRAHAM
Vice Chairman

JOHN DELEEUEW
Member

Report Date: May 18, 2026

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this accident on July 5, 2024. NTSB investigators began arriving on scene on July 6. The NTSB team consisted of an investigator-in-charge, hazardous materials investigators, an operations investigator, a signal and train control investigator, a locomotive event recorders specialist investigator, a meteorology investigator, and a materials laboratory investigator. The parties to the investigation are the Federal Railroad Administration; the Pipeline and Hazardous Materials Safety Administration; Canadian Pacific Kansas City Limited; Union Tank Car Company; Trinity Industries Leasing Company; American Industrial Transport Inc.; Engineered Controls International; the International Association of Sheet Metal, Air, Rail and Transportation Workers; Brotherhood of Maintenance of Way Employees; and the Brotherhood of Locomotive Engineers and Trainmen.¹¹¹

¹¹¹ The Brotherhood of Maintenance of Way Employees Division spells the word "Employees" in its name with one final e.

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 Pipeline and Hazardous Materials Safety Administration:

R-26-1

Issue guidance for the selection of an optimal pressure relief device based on the characteristics of the poison inhalation hazard material transported in a tank car.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2, Thermal Protection Standards. Information supporting (b)(1) and (b)(2) can be found on pages 67–70; (b)(3) is not applicable.

R-26-2

Develop and implement new thermal performance criteria for tank cars carrying liquefied gases classified as poison inhalation hazard materials that allow for no release of the tank car’s lading during a fully engulfing pool fire except through reclosing pressure relief devices.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2, Thermal Protection Standards. Information supporting (b)(1) and (b)(2) can be found on pages 67–70; (b)(3) is not applicable.

R-26-3

In coordination with the Association of American Railroads, identify the appropriate amount of separation between tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of poison inhalation hazard tank cars being exposed to pool fire conditions.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.6, Hazards in Tank Car Placement. Information supporting (b)(1) and (b)(2) can be found on pages 71-76; (b)(3) is not applicable.

R-26-4

Using the results of the determination described in R-26-3, reduce the vulnerability of tank cars transporting liquefied gases designated as poisonous by inhalation, including anhydrous ammonia, by requiring their physical separation from flammable hazardous materials when placed in a train.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.6, Hazards in Tank Car Placement. Information supporting (b)(1) and (b)(2) can be found on pages 71-76; (b)(3) is not applicable.

To the Association of American Railroads:**R-26-5**

Inform your members of the circumstances of this derailment and encourage them to (1) review and revise as necessary their culvert inspection procedures to include a requirement to perform internal inspections either on foot when safe or by using technology, such as cameras or remotely operated vehicles, and (2) provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.3, Insufficient Culvert Inspection Practices. Information supporting (b)(1) and (b)(2) can be found on pages 55-59; (b)(3) is not applicable.

R-26-6

Revise the formula for required pressure relief device flow capacity specified in Appendix A of your *Specifications for Tank Cars* and the requirements for pressure relief devices and thermal protection systems to ensure the survivability of tank cars carrying poison inhalation hazard materials in engulfing pool fire conditions.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.4.1, Pressure Relief Devices. Information supporting (b)(1) and (b)(2) can be found on pages 61–67; (b)(3) is not applicable.

R-26-7

Support the Pipeline and Hazardous Materials Safety Administration in identifying the appropriate amount of separation between tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, and those transporting flammable hazardous materials to reduce the likelihood of poison inhalation hazard tank cars being exposed to pool fire conditions.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.6, Hazards in Tank Car Placement. Information supporting (b)(1) and (b)(2) can be found on pages 71–76; (b)(3) is not applicable.

R-26-8

Using the results of the determination described in R-26-3, modify train placement instructions contained in your *United States Hazardous Materials Instructions for Rail* to ensure that tank cars transporting poison inhalation hazard materials, including anhydrous ammonia, are physically separated from flammable hazardous materials.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.6, Hazards in Tank Car Placement. Information supporting (b)(1) and (b)(2) can be found on pages 71–76; (b)(3) is not applicable.

To the American Short Line and Regional Railroad Association:**R-26-9**

Inform your members of the circumstances of this derailment and encourage them to (1) review and revise as necessary their culvert inspection procedures to include a requirement to perform internal inspections either on foot when safe or by using technology, such as cameras or remotely operated vehicles

and (2) provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.3, Insufficient Culvert Inspection Practices. Information supporting (b)(1) and (b)(2) can be found on pages 55-59; (b)(3) is not applicable.

To Canadian Pacific Kansas City Limited:

R-26-10

Revise your culvert inspection procedures to require every culvert be inspected internally, either on foot when safe or by using technology, such as cameras or remotely operated vehicles.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.3, Insufficient Culvert Inspection Practices. Information supporting (b)(1) and (b)(2) can be found on pages 55-59; (b)(3) is not applicable.

R-26-11

Revise your culvert inspection procedures to provide detailed rating guidance specific to each type of culvert construction, similar to the American Association of State Highway and Transportation Officials' *Culvert & Storm Drain System Inspection Guide* as recommended by the American Railway Engineering and Maintenance-of-Way Association, and require remedial actions to be taken within set timeframes, when necessary.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 2.3, Insufficient Culvert Inspection Practices. Information supporting (b)(1) and (b)(2) can be found on pages 55-59; (b)(3) is not applicable.

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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 RRD24LR012. 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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