



National Transportation Safety Board
Washington, D.C. 20594

Date: January 19, 2021

Hazardous Materials Group Factual Report

A. Accident Identification

Operator: Union Pacific
Accident No.: RRD20LR005
Accident Type: Freight Train Derailment/Release/Fire
Location: Tempe, Arizona
Date of Accident: July 29, 2020

B. Hazardous Materials Group Members

Rachael Gunaratnam
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Hazardous Materials Accident Investigator
National Transportation Safety Board

Isaac Bonds
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Director, Hazardous Materials Management-
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C. Synopsis

See Accident Summary on the docket.

D. Hazardous Materials Description

The UP mixed-freight train, MTUPX-29 had a total of 13 hazmat cars listed on the consist at the time of the incident, however one empty, asphalt (UN3257) residue tank car (VMSX 5313) was added from Randolph, Arizona that was not listed. The following loaded hazmat cars were listed at the time of the derailment in Table 1.¹

Table 1: List of hazardous materials on train MTUPX-29 at the time of the derailment

Consist No.	Car no.	Hazmat	UN	Class/PG
29	NATX301521	Alcohols, N.O.S. (Denatured Ethanol)	1987	3/II
30	DBUX301209	Alcohols, N.O.S. (Denatured Ethanol)	1987	3/II
31	TILX192919	Alcohols, N.O.S. (Denatured Ethanol)	1987	3/II
38	GATX 1384	Cyclohexanone	1915	3/III
40	ACFX 72540	Cyclohexanone	1915	3/III
41	GATX 90208	Cyclohexanone	1915	3/III
48	GATX 6479	Sulfuric acid	1830	8/II
49	NATX 160112	Sodium hydroxide	1824	8/II
74	UTLX 942353	Other Regulated Substance, Liquid, N.O.S. (Methylene Diphenyl Diisocyanate)	NA3082	9/III
75	ACFX 76974	Other Regulated Substance, Liquid, N.O.S. (Methylene Diphenyl Diisocyanate)	NA3082	9/III
81	GATX 6360	Sulfuric acid	1830	8/II
82	GATX 6326	Sulfuric acid	1830	8/II
90	CBTX 741880	Toluene	1294	3/II

¹ See NTSB docket for tra in consist.

The only car reported leaking was GATX 90208, which was loaded with cyclohexanone, classified as a Class 3 flammable liquid, packing group III. The safety data sheet (SDS) listed cyclohexanone by its trademark name Nadone® and described the material as a clear, colorless liquid that has a “mint-like acetone-like” odor. The following chemical properties were listed:

- Melting point/range: -45 °C [-49 °F]
- Boiling point/boiling range: 155.6 °C [312.08 °F]
- Flash point: 111 °F (44 °C); Method: closed cup
- Evaporation Rate: ca. 0.30; Method: Compared to Butyl acetate.
- Lower Explosion limit: 1.10 %(V)
- Uppers explosion limit: 9.40 %(V)
- Vapor Pressure: 5.27 hPa at 20 °C (68 °F)
- Vapor density: 3.4 Note: (Air = 1.0)
- Density: 0.95 g/cm³ at 20 °C [68°F]
- Water solubility: ca. 150 g/l
- Ignition temperature: 420 °C [788 °F]
- Molecular weight: 98.16 g/mol

DOT Emergency Response Guidebook (ERG) Guide 127 recommends a downwind evacuation of at least 300 meters (1,000 feet) for a large spill of cyclohexanone. ²

See Attachment 1 – Safety Data Sheet

E. Shipper Information

The UP mixed-freight train, MTUPX-29, was transporting three tank cars of cyclohexanone, which is classified by U.S. Department of Transportation (DOT) as a Class 3 (flammable liquid), packing group III. The shipper and lessor of the tank cars was AdvanSix, a manufacturer of nylon 6 resin, chemical intermediates and ammonium sulfate fertilizer, with facilities in Pennsylvania and Virginia. The shipment of cyclohexanone came from the AdvanSix facility in Hopewell, VA, a single-site producer of caprolactam, which is the primary feedstock in the production of nylon polymer used in

² *Emergency Response Guidebook* (Washington, DC, U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration 2020).

carpets, plastics, and films. Cyclohexanone is one of the main chemicals used for the synthesis of caprolactam.

AdvanSix loaded the cyclohexanone into the following tank cars the company leased from the tank car owners GATX 1384 and GATX 90208 from GATX; and ACFX 72540 from Union Tank Car. CSX picked up the shipment on July 15, 2020 and interchanged with UP in East St. Louis. The three cars were destined to Univar Solutions, the consignee, in Phoenix, AZ. Univar Solutions is a leading specialty chemical ingredient and solutions provider.³

See Attachment 2 - Waybills for cyclohexanone tank cars

i. Pretransport Inspections

AdvanSix completed a “pre-loading” checklist and had a third-party outbound inspection for all three tank cars and inspected the following, amongst other items:

- Placards
- Fittings
- Exterior appearance (e.g. spillage, corrosion, stenciling for the entire)
- All valving, connections & housing checked for operations/leaks prior to loading
- All hatches, covers, and valves caps closed, sealed
- Gauging devices and dome mechanism checked for proper operation
- Tank car inspected for spills and leak
- Chemical ID tags in place
- BOV cap removed and inspect gasket

The AdvanSix checklist passed the shipment with no issues noted. The 3rd party outbound inspection noted only “2" plug loose on inspection” for GATX 1384 and was tightened.

See Attachment 3 - Pretransport Inspections

³ See <https://www.univarsolutions.com/>.

ii. Loading and Outage Volumes

According to DOT regulations at 49 CFR 173.24b, the required minimum outage for tank cars transporting flammable liquids must be equal to or greater than 1% of the total capacity of a tank or a compartment of the tank, with lading density corrected to a reference temperature of 115°F for a non-insulated DOT-111 tank cars. In addition to not exceeding the maximum filling limit or filling density, tank cars may not be loaded in excess of the stenciled load limit and the gross rail load (GRL = light weight + tare weight) and must not exceed 263,000 pounds.

AdvanSix loaded the three cars (GATX 1384, ACFX 72540, GATX 90208) on three different days on July 10-12, 2020:

July 10 GATX 1384	Volume: 23,873.41-gals	Loading Temperature: 82°F
July 11 GATX 90208	Volume: 23,316.45-gals	Loading Temperature: 82°F
July 12 ACFX 72540	Volume: 21,405.06-gals	Loading Temperature: 81°F

The shipper also provided the thermal coefficient of expansion of cyclohexanone of 0.00095 at 20°C (68 °F) and a specific gravity of .927 at 115°F. Outage calculations performed by Federal Railroad Administration (FRA) showed that the tank cars were loaded within the 1% outage requirement.⁴ ACFX 72450 as loaded short of 1,424 gallons and GATX 1384 was loaded short of 1,451 gallons of the maximum allowable load. GATX 90208 was loaded short of about 2000 gallons of the maximum allowable load.

See Attachment 4 -Outage calculations

iii. Tank Car Specifications

i. GATX 90208

GATX 90208 was manufactured by Trinity Industries, Inc. on February 9, 1999 and passed its last requalification inspection in 2019; the next inspection was due in 2029. At the time of

⁴ FRA research suggests that outage influences tank car puncture resistance, with greater energy required to puncture tank car shells as outage is increased.

construction, the tank car design was required to meet the provisions of 49 CFR 179.200-7. GATX 90208 certificate of construction indicated:

- tank car shell and head was constructed of ASTM A516-70 carbon steel plates
- tank car shell and head material thickness was 7/16 inch-thick
- no thermal protection
- no headshield
- pressure relief device set at 75 psi
- manway cover includes 6 hinge bolts

F. Hazardous Materials Released

UP reported that 2,201 gallons of cyclohexanone released from GATX 90208. During the tank car examination and load transfers, GATX 90208 was the only car observed to have lost some of its lading that pooled on the ground on a roadway and was contained by the natural contours of the ground; sandbags were added for extra containment. The cyclohexanone was reported to not have impacted the waterway. On the day of the incident, hazardous material response teams stopped the leak at 5:30 p.m., had the tank car upright at 5:50 p.m., and was later staged at 7:30 p.m. The released cyclohexanone did not ignite (Figure 1). UP drone footage showed fire damage on the lumber car TTZX 862290 and its load that fell off the car (Figure 2).

See Attachment 5 -UP Information on hazmat containment

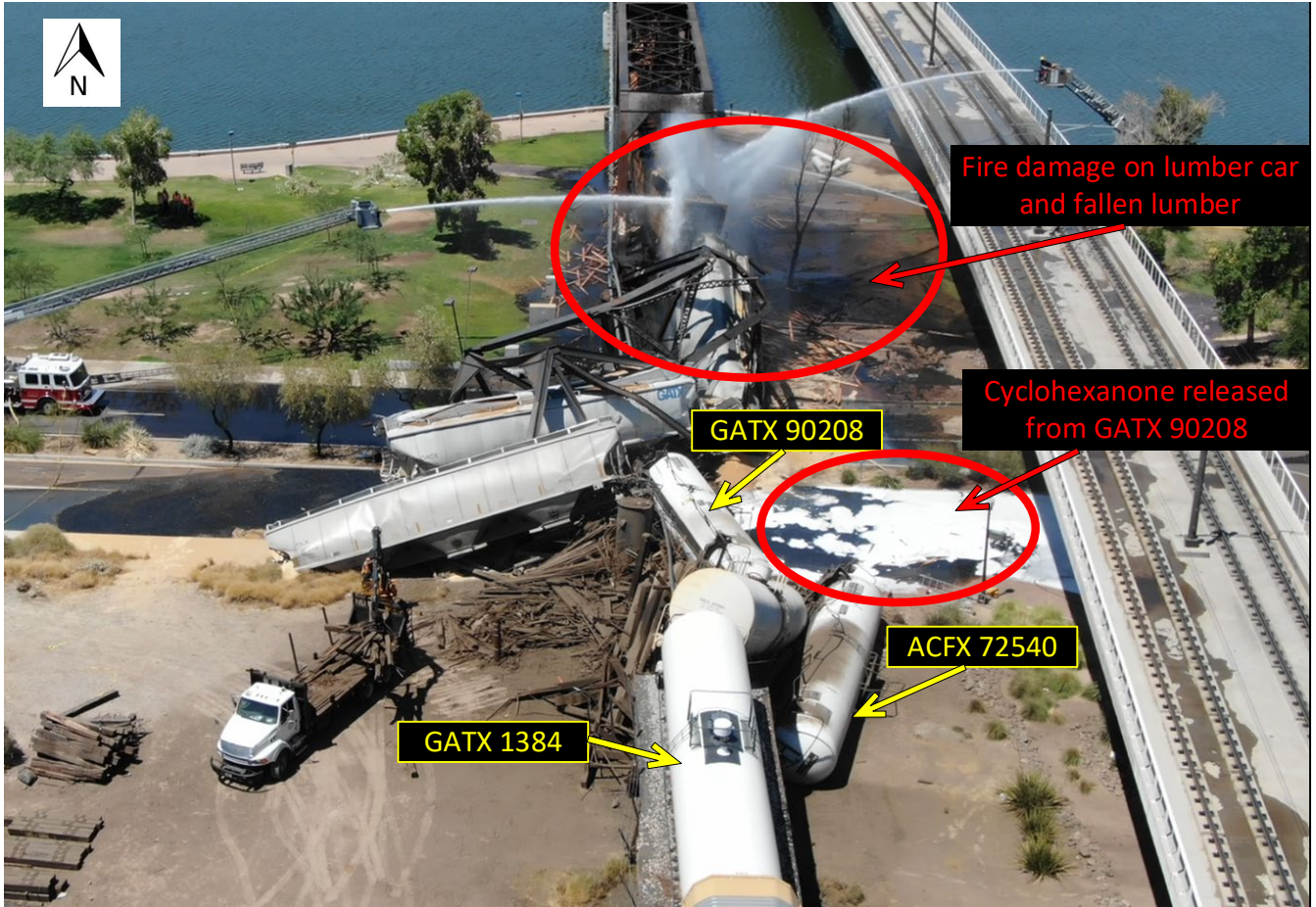


Figure 1: Drone footage of derailed cyclohexanone tank cars and fire damage



Figure 2: Aerial view of burned lumber car TTZX 862290 in front of soybean car TILX 540850

Union Pacific shipped three tank cars of recovered cyclohexanone to a new consignee, Veolia North America, to their facility in Henderson, Colorado. UP transferred two of the loads into two other tank cars. UP recovered the full load from ACFX 72450 and transferred it into another tank car, TILX 270025. GATX 90208 load was also transferred into another tank car, GATX 940. The third car GATX 1384 was transported to Tucson, AZ, under a One-Time Movement Approval (FRA movement approval) and then transloaded at this location into tank car GATX 945.

G. Hazmat Tank Car Damage Assessment

At the time of the accident, the three cyclohexanone cars had entered onto the bridge approach but not on the bridge itself. Two of the three cyclohexanone tank cars fell off the elevated track (GATX 90208 and ACFX 72540), and the third (GATX 1384) derailed, however, did not fall off the track. A non-hazmat, tank car loaded with latex liquid rubber was positioned between ACFX 72450 and GATX 1384 (see Figure 1).

The three cyclohexanone cars were all unjacketed, DOT-111A100W1 and were the focus of the tank car examination, which was led by FRA. The Arizona Corporation Commission (ACC), which oversees rail safety in the state, the Pipeline and Hazardous Materials Administration, and UP participated in the tank car examination. The sulfuric acid tank car (GATX 6479) was also examined

because of observed tank shell damage, but it was later determined this was due to wreckage clearing and re-railing activities. Three ethanol tank cars were also assessed but no derailment damage was observed on these cars.

GATX 90208

- Lading released 2201 gallons from the manway
- Missing swing bolt (Figure 3 and Figure 4)
- B-end stub sill bent
- BOV nozzle missing
- After derailment, laid to rest on its left side (Figure 1)



Figure 3: GATX 90208: missing swing bolt on manway (photograph courtesy of Union Pacific Railroad)



Figure 1: GATX 90208 PRD housing and manway with a missing bolt (circled yellow) (photograph courtesy of FRA)

ACFX 72540

- No lading released
- Several dents on the left side of the tank car shell
 - 64 in (length) x 58 in (height) x 1 ft 2 in (depth)
 - 60 in (length) x 24 in (height) x 2 ft 3/8 in (depth)
 - 16 in (length) x 12 in (height) x 3/16 in (depth)
- Dent on the protective housing, 60 in x 24 in x 2 ft 3/8 (Figure 5)
- After derailment, tank car laid on its left side, B-end leading (Figure 6)



Figure 5: ACFX 72540: Dents on left side and PRD housing (photograph courtesy of PHMSA)



Figure 6: ACFX 72450 post-derailment position before staging (photograph courtesy of PHMSA)

GATX 1384

- No lading released
- Dent on the B-end head measured 44 in (length) x 42 in (width) x 7 in (depth) (See Figure 7)



Figure 7: GATX 1384: Dent on the B-end head (photograph courtesy of PHMSA)

See Attachment 6 - Damage Assessment Work Sheets GATX 90208, ACFX 72540, GATX 1384

H. Applicable Tank Car Regulations and Industry Standards

On December 4, 2015, the Fixing America's Surface Transportation Act of 2015 (FAST Act) was signed into legislation, directing the Secretary of Transportation to make specific regulatory amendments to the tank car design standards and a phase out schedule to be codified in the DOT regulations, amongst other transportation requirements. The Pipeline and Hazardous Materials Safety Administration (PHMSA) had published earlier a final rule (HM-251) on May 8, 2015, revising the Hazardous Materials Regulations (HMR) on tank car design standards for non-pressure tank car tanks (49 CFR Part 179.200). HM-251 mandated the replacement of DOT Specification 111 tank cars transporting Class 3 flammable liquid with a more robust tank car, the DOT Specification 117; or retrofit a non-jacketed DOT 111 tank car to meet the requirements of a DOT Specification 117R.

The FAST Act mandated a phase-out schedule for these cars transporting unrefined petroleum products, ethanol and other class 3 flammable liquids (49 CFR Part 173.242). On August 15, 2016,

PHMSA issued another final rule, HM-251C, to codify the phase out schedule. The three cyclohexanone cars in the non-jacketed DOT-111 tank cars are scheduled to be out of service by May 1, 2029.⁵

The Association of American Railroads (AAR) issues a *Manual of Standards and Recommended Practices (MSRP), Specification for Tank Cars, M-1002*, which lists specifications for tank car design fabrication and construction. Provisions listed for manway covers for nonpressure cars are under Appendix E.

⁵ Hazardous Materials: FAST Act Requirements for Flammable Liquids and Rail Tank Cars, 81 Fed. Reg. 53935 (August 15, 2016).

List of Attachments

- ATTACHMENT 1 – Safety Data Sheet
- ATTACHMENT 2 – Waybills for cyclohexanone tank cars
- ATTACHMENT 3 – Pretransport Inspections
- ATTACHMENT 4 – Outage Calculations
- ATTACHMENT 5 – UP Information on hazmat containment
- ATTACHMENT 6 – Damage Assessment Work Sheets (GATX 90208, ACFX 72540, GATX 1384)

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