HAZARDOUS MATERIALS GROUP
FACTUAL REPORT

Derailment of Union Pacific Railroad Train UEBLTG 20 on April 24, 2019, with Subsequent Hazardous Materials Release

Fort Worth, Texas

RRD19FR007

Report Date: August 19, 2019

Contents:

A. Accident Identification

Carrier: Union Pacific Railroad
Train No.: UEBLTG 20
Location: Fort Worth, Texas
Date/Time: April 24, 2019, 12:33 A.M. CDT
NTSB No.: RRD19FR007

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C. Accident Summary

On April 24, 2019, about 12:33 a.m. central daylight time, Union Pacific Railroad (UP) train UEBLTG 20, a high-hazard flammable key train carrying denatured ethanol, derailed in Fort Worth, Texas. The train consisted of three lead locomotives, two buffer cars, and 96 loaded tank cars. The train was 6,122 feet long, and it weighed 13,230 tons. At the time of the derailment, the train was travelling southbound at 26 mph on 30-mph speed-restricted track.

The derailment of the train occurred near milepost 48.8 on the UP Midlothian Subdivision. Of the 96 loaded tank cars, 26 derailed. The derailed tank cars were in positions No. 17 through No. 42.[1] Three tank cars were breached; the three tank cars leaked 65,270 gallons of denatured ethanol. The released ethanol ignited and formed pool fires. The local police evacuated between 6 and 10 nearby homes; some residents refused to evacuate. Some of the released ethanol entered a nearby tributary of the Trinity River. No individuals were injured. However, three horses in a barn were killed and three horses were injured.

UP officials separated the first 14 non-derailed tank cars behind the locomotives and the two buffer hopper cars loaded with sand away from the derailed and burning tank cars. The noninvolved tank cars at the rear of the train were also moved away from the derailed and burning tank cars. The denatured ethanol was a highly flammable mixture of ethanol and natural gasoline and was intended for use as a motor vehicle fuel. (Figure 1.)

Figure 1: Accident scene, Ft. Worth, Texas.

[1] Union Pacific train consists are numbered from the back of a train, with the furthest railcar from the locomotives at position number 1. Therefore, the original train consist indicated the derailed tank cars were in positions 57 through 82.

ATTACHMENT 1 – UNION PACIFIC LABELED AERIAL PHOTOGRAPHS, DERAILMENT SCENE, APRIL 24, 2019

D. Emergency Response

The FWFD chief told investigators the incident was initially reported as a commercial structure fire, but firefighters quickly learned the incident involved a hazardous materials fire. About 12:38 a.m. on April 24, a citizen notified the Fort Worth Fire Department (FWFD) via 911 that a train was on fire. By 12:54 a.m., Union Pacific Railroad advised the fire department that the rail cars were carrying ethanol and that its hazmat supervisor was enroute. The FWFD focused on scene control and advised residents to leave the area. No mandatory evacuation was ordered. The fire department notified the Fort Worth Division of Environmental Quality, the Texas Department of Environmental Quality, and the Fort Worth Emergency Operations Center.

The FWFD reported their access to the incident scene was difficult due to heavy rain, mud, and terrain. Fire fighters observed that tank cars were spilling burning product into Sycamore Creek. FWFD Battalion 1 took command and declared a Level 3 Hazmat incident due to the amount of ethanol involved and the potential impact on surrounding neighborhoods and the environment.[2] FWFD incident commanders interacted with multiple Union Pacific Railroad representatives that were integrated into their unified command. The incident commander told NTSB investigators that once the burning product was identified as ethanol, the fire department and Union Pacific Railroad quickly responded with alcohol-resistant foam trailers. The FWFD incident commander in consultation with Union Pacific ultimately decided the best course of action was to allow the fire to extinguish itself.

The FWFD reported that despite the proximity of burning railcars to nearby residents, no residents were forced to leave. According to the FWFD report, a large horse barn burned and at least one horse was killed (later determined to be three). No other injuries were reported. The incident commander told NTSB investigators that although he did not believe the fire posed an imminent threat to nearby residents, two fire apparatus were stationed in the adjacent neighborhood in the event of a sudden ethanol release from other tank cars.

The FWFD command vehicle was delivered and set up to facilitate a growing and complex command structure. The department reported that because of low visibility and

[2] A Level 3 hazardous materials incident refers to an emergency response that is beyond the capabilities of a single state or regional response team and requires additional assistance from state and federal agencies and private industry. These incidents generally pose extreme, immediate, and/or long-term risk to the environment and public health.

"unpredictable powerline placement," the camera boom was raised into high-voltage overhead power lines. The command unit "became energized and untenable." One fire chief reported that he felt a slight electrical shock when attempting to enter the command vehicle. The unit was evacuated before it caught fire and its loss did not ultimately impede the emergency response effort (Figure 2).

Figure 2. Destroyed Fort Worth Fire Department incident command vehicle.

On April 26, 2019, the Hazardous Materials Group interviewed the neighboring property owner, who owns the parcel situated at the 1200 block of Adkins Street bordering the derailment site. He told investigators about the death of 3 horses and injury to 3 additional horses from fire that destroyed his horse corral, stables, and tack shed (Figure 3). On the night of the accident, he was summoned to the scene by another nearby resident who lives on the opposite side of Adkins Street. The neighboring property owner, who lives a short distance from the corral, arrived on scene and observed fire jumping over the ditch separating the rail tracks from his property. He said several of his relatives risked injury to release other horses from the stables (there were 19 in all) as the fire became more intense. The neighboring property owner said he observed a vigorous pool fire but did not witness any energetic fireballs or explosions.

Figure 3. Investigators examine destroyed horse stables next to the derailment scene.

The neighboring property owner also told investigators that the railroad right-of-way had a history of flooding, with railway ballast being washed downstream in the creek. He said that residents complained about the flooding at a community town hall meeting within the past two months. He said on the day prior to the accident, an inspector with the City of Fort Worth (agency and identity unknown to the neighboring property owner) subsequently toured the site to examine evidence of flooding and an alluvial fan of railroad ballast that had accumulated downstream of the derailment site.

ATTACHMENT 2 – INCIDENT COMMANDER'S INTERVIEW TRANSCRIPT, FORT WORTH FIRE STATION 17, APRIL 26, 2019
ATTACHMENT 3 – FORT WORTH FIRE DEPARTMENT INCIDENT REPORT, APRIL 26, 2019
ATTACHMENT 4 – ADJACENT PROPERTY OWNER INTERVIEW TRANSCRIPT, APRIL 24, 2019

E. Hazardous Materials Information

Shipment Origination

On April 20, 2019, Cargill, Incorporated loaded the train at its Blair, Nebraska ethanol refinery. The bills of lading indicate the train was destined to Trafigura Trading LLC, C/O Texas International Terminal in Galveston, Texas.

The Cargill ethanol refinery is situated within a 650-acre industrial complex, about 30 miles north of Omaha, Nebraska. The facility is operated by 540 employees and 400 contractors. The facility has a production capacity of about 195 million gallons of ethanol and originates about 75 ethanol unit trains annually. Cargill's Blair, Nebraska facility also produces dextrose, corn syrup, livestock feed ingredients, and crude corn oil. [3]

Cargill certified that the material was properly classified, described, packaged, marked and labeled, and was in proper condition for transportation. Cargill loading technicians and contractors inspected the top and bottom of all tank cars following the loading process to verify compliance with Department of Transportation requirements. Cargill technicians checked the bottom fittings for tool-tightness, checked for missing seals, tank car wheel anomalies, verified there were no visible leaks, checked placard holders, and verified that no railcar repairs were needed. Cargill conducted a final inspection in its railyard prior to assembling the loaded tank cars into the train.

Hazardous Materials Description

The DOT shipping description used on the train consist was UN1987 Alcohols, N.O.S. (Ethanol, Gasoline), Class 3, PG II. The Cargill bill of lading further describes the product

[3] For more information see the company website at: https://www.cargill.com/

as denatured alcohol ASTM D4806 N.O.S. with corrosion inhibitor.

The safety data sheet (SDS), most recently updated 4/21/2009, identified the following hazardous constituents:

- ethyl alcohol 95%
- natural gasoline 2 – 5%

The SDS identified the following relevant chemical and physical properties:

- flash point as 50-55°F.[4]
- lower explosive limit (LEL) was 3.3%
- upper explosive limit (UEL) was 19.0%
- Reid vapor pressure (RVP) 3.99 psi (natural gasoline denaturant)
- Vapor density (air = 1) 1.6
- Boiling point 165 – 175°F

Cargill provided certificates of analysis for in-house testing of 5 ethanol batches manufactured between April 13 - 17, 2019, which were included in this train. The following relevant test results for each batch are noted in Table 1.

Table 1. Cargill ethanol batch assays, selected parameters.

Parameter	Limit	Result 4/13/19	Result 4/14/19	Result 4/15/19	Result 4/16/19	Result 4/17/19	Avg.
Ethanol Purity	92.1 %	97.02%	97.02%	96.98%	97.05%	96.87%	96.99%
Methanol	0.5 vol %	0.027%	0.030%	0.028%	0.043%	0.030%	0.032%
Specific Gravity	0.78393 – 0.79718	0.79415	0.79440	0.79420	0.79445	0.79450	0.79434
API Gravity	46.0 – 49.0	46.7	46.6	46.7	46.6	46.6	46.6
Benzene	0.06 vol % max	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Aromatics	1.7 vol % max	0.14%	0.14%	0.14%	0.13%	0.15%	0.14%
Olefins	0.5 vol %	0.16%	0.15%	016%	0.15%	0.16%	0.16%

According to the SDS, water is not effective to extinguish an ethanol fire until the alcohol contains approximately 80% water.

According to the supplemental hazardous materials information appended to the train consist, potential hazards include fire and explosion. The material is highly flammable and is easily ignited by heat, sparks, or flames. Vapors may form explosive mixtures with air and may travel to a source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low lying areas. Runoff to sewers may create fire or explosion hazard. Containers may explode when heated.

[4] The safety data sheet incorrectly references the flash point of undenatured, or pure ethanol. Denatured fuel ethanol typically has a flash point of -5°F to +19°F.

Inhalation or contact with material may irritate or burn skin and eyes. Fire may produce irritating, corrosive, and toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire may cause pollution.

For a large spill, the ERG recommends downwind evacuation of at least 1,000 feet. If a rail car is involved in a fire, isolate and evacuate for ½ mile in all directions and stay away from tanks engulfed in fire. For fire involving denatured ethanol, alcohol resistant firefighting foam should be used.

Hazardous Materials Released

The estimated the amount of released denatured ethanol was about 65,270 gallons, as shown in a mass-balance calculation shown in Table 2.

Table 2. UP calculation of the amount of ethanol released in this accident.

	Shipper Loaded Amt	Amt Remaining	Total Loss			
UTLX 209301	28821	19709	9112			
TCBX 194145	28779	0	28779			
UTLX 209403	28868	1489	27379			
		Total Relase	65270			
Notes:	1	Shipper provided information in tab 2				
	2	UTLX 209301 estimated using field measured outage (44 inches)				
	3	UTLX 209301 calculated using UTLX web site strapping chart				
	4	UTLX 209301 calculated without taking into consideration the large dent				

ATTACHMENT 5 – SAFETY DATA SHEET, DENATURED FUEL ETHANOL
ATTACHMENT 6 – CARGILL INCORPORATED ETHANOL CERTIFICATES OF ANALYSES
ATTACHMENT 7 – HAZARDOUS MATERIAL WAYBILL, APRIL 20, 2019
ATTACHMENT 8 – STRAIGHT BILLS OF LADING, APRIL 20, 2019

F. Union Pacific Train UEBLTG 20

UP train UEBLTG 20 was classified as a high hazard flammable unit train[5] and "key train"[6] with 3 head-end locomotives, two covered hopper buffer cars and 96 loaded tank cars containing denatured ethanol. The train length was 6,122 ft. and trailed 13,230 tons.

The train departed Ney Yard, Texas on April 24, 2019, at 00:26 a.m. At the time of the accident, the train was traveling southbound on the Midlothian Subdivision. The derailment occurred at MP 48.8 at 00:33 a.m. The derailed tank cars involved Line 57 (42 from the

[5] A high-hazard flammable train (HHFT) means a single train transporting 20 or more loaded tank cars of a Class 3 flammable liquid in a continuous block, or a single train carrying 35 or more loaded tank cars of a Class 3 flammable liquid throughout the train consist. Additional requirements such as speed restrictions and enhanced braking systems also apply.

[6] Definition of "key train" is provided by Association of American Railroads (AAR) publication OT-55-P, *Recommended Railroad Operating Practices for Transportation of Hazardous Materials*, January 27, 2015. "Key trains" are subject to speed restrictions and other operating criteria.

head) through Line 82 (17 from the head). Tank cars in lines 57(42), 81(18), and 82(17) were rerailed and removed from the area. Remaining derailed tank cars were lifted from the Sycamore Creek by crane and staged adjacent to the derailment location for inspection and damage assessment.

ATTACHMENT 9 – TRAIN CONSIST UEBLTG 20, APRIL 23, 2019

G. Tank Car Loading and Outage

Cargill's loading technicians derived loading volumes by performing outage calculations for each tank car using a programmed application into which they inputted the stenciled load limit, light weight, product temperature, density, and coefficient of expansion. As shown in Table 3, the loaded weight for each of the derailed tank cars, according to the train waybills, did not exceed stenciled load limits.

Table 3. Tank car weight and volume loaded, and outage calculations

Line Number	Car Number	Load Limit (lb)	Loaded Amount (lb)	Corrected Outage by weight	Water Capacity (gal)	Loaded Amount (gal)	Corrected Outage by Volume
82/17	TILX 199335	206,600	188,826	8.0%	30,110	28,697	5%
81/18	TILX 199040	207,100	187,049	9.1%	30,010	28,427	6%
80/19	TILX 191488	205,600	187,885	8.0%	30,170	28,554	6%
79/20	TILX 198946	206,800	188,444	8.3%	30,140	28,639	6%
78/21	TILX 194329	206,400	188,898	7.9%	30,070	28,708	5%
77/22	TILX 351873	198,200	189,813	3.6%	31,690	28,847	10%
76/23	UTLX 209403	206,300	189,951	7.3%	30,270	28,868	5%
75/24	TILX 363368	195,400	188,444	2.9%	30,360	28,639	6%
74/25	TCBX 194145	195,600	189,365	2.5%	30,160	28,779	5%
73/26	GATX 225797	194,800	186,720	3.5%	30,200	28,377	7%
72/27	TILX 198738	207,500	188,767	8.4%	30,070	28,688	5%
71/28	TILX 351793	198,450	190,260	0.1%	31,640	29,915	9%
70/29	FURX 160011	195,300	190,280	1.9%	30,450	28,918	6%
69/30	TILX 352058	197,900	190,326	3.2%	31,750	28,925	10%
68/31	TILX 363454	195,500	190,221	2.0%	30,330	28,909	5%
67/32	UTLX 207573	205,900	189,550	7.3%	30,240	28,807	5%
66/33	FURX 160024	195,300	189,911	2.1%	30,490	28,862	6%
65/34	UTLX 209301	205,700	189,642	7.2%	30,260	28,821	5%
64/35	TILX 199078	206,900	188,359	8.3%	30,060	28,626	5%
63/36	FURX 160030	195,400	188,010	3.1%	30,480	28,573	7%
62/37	TILX 192495	206,500	189,444	7.6%	30,170	28,791	5%
61/38	TILX 194312	206,700	188,207	8.3%	30,160	28,603	6%
60/39	TILX 363442	195,800	189,898	2.4%	30,290	28,860	5%
59/40	UTLX 209496	205,600	189,661	7.1%	30,250	28,824	5%
58/41	TILX 191499	205,500	189,629	7.1%	30,210	28,819	5%

= breached

According to 49 CFR 173.24(b), 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 at a reference temperature of 43.3°C (110°F) for insulated tanks or tanks having a thermal protection system incorporating a metal jacket with certain thermal performance criteria. 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) must not exceed 286,000 pounds (263,000 pounds for the single derailed DOT-111 tank car TCBX194145).

ATTACHMENT 10 – CARGILL RESPONSE TO NTSB INFORMATION REQUEST, MAY 3, 2019

H. Derailed Tank Car Specifications

Title 49 of the Code of Federal Regulations (CFR) Part 179 outlines the federal requirements for tank cars. Subpart B of Part 179 contains general design requirements, while Subpart D contains the specifications for non-pressure tank car tanks. Additional tank car industry standards, incorporated in the HMR by reference, are the Association of American Railroads (AAR) Manual of Standards and Recommended Practices, Section C-Part III, Specifications for Tank Cars, Specification M-1002.

DOT-111 tank cars can be fabricated out of several plate materials that must meet the specifications that are outlined in 49 CFR 179.200-7. The tank cars involved in this accident were constructed from carbon steel plates. The standard provides that the carbon steel heads and shells must be constructed of TC 128 Grade B steel or A5l6-70 steel.[7] The specification requirement for DOT-111A100W1 requires a minimum plate thickness of 7/16 inch thickness.[8]

DOT-111 tank cars ordered after March 1, 2011 and later converted to Specification DOT-117R were originally constructed to the enhanced general service AAR CPC-1232 standard. These construction requirements are specified in the AAR Manual of Standards and Recommended Practices, Specifications for Tank Cars, M-1002, which states the following:

> Class 111 tank cars used to transport Packing Group I and II materials with the proper shipping names Petroleum Crude Oil, Alcohols, N.O.S., and Ethanol and Gasoline Mixture, must have heads and shells constructed on normalized TC128 Grade B steel or normalized A516-70 steel. Tank car

[7] Tank cars manufactured after the CPC – 1232 standard – normalized
[8] See 49 CFR 179.201-1 – Individual Specification Requirements

> heads must be normalized after forming, unless approval is granted by the AAR Executive Director of Tank Car Safety on the basis that a facility has demonstrated that its equipment and controls provide an equivalent level of safety. For tanks constructed on normalized TC128 Grade B steel, non-jacketed tanks must be at least 1/2-in. thick and jacketed cars must be at least 7/16-in. thick. For tanks constructed of normalized A516-70 steel, non-jacketed cars must be at least 9/16-in. thick and jacketed cars must be at least 1/2-in. thick. In all cases the cars must be equipped with at least 1/2-in. half-head shields.

On May 1, 2015, PHMSA published final rule (HM-251) requiring that after October 1, 2015, new tank cars manufactured for use in a High Hazard Flammable Train (HHFT)[9] service must be constructed to the specification DOT-117 or 117P performance standard as specified in Subpart D–Specifications for Non- Pressure Tank Car Tanks. Among the specification 117 requirements are:

- 9/16-inch normalized TC-128 steel minimum for heads and shells
- Full height ½ inch thick head shield
- Thermal protection system
- Minimum 11-gauge jacket
- Top fittings protection
- Enhanced bottom outlet handle design to prevent unintended actuation during a train accident
- 286,000 lbs. GRL authorized

In accordance with 49 CFR 179.202-13, existing DOT-111 and CPC-1232 tank cars in continued HHFT service must be retrofitted to specification DOT-117R. The retrofit or replacement deadline for jacketed CPC-1232 tank cars in ethanol service, such as those retrofitted tank cars involved in this accident, is May 1, 2025. Non-jacketed CPC-1232 tank cars in ethanol service must be phased out by July 1, 2023, and both non-jacketed and jacketed DOT-111 cars in ethanol service must be phased out by May 1, 2023. Retrofitted tank cars require full height headshields, minimum 11-gauge jackets, thermal protection systems, enhanced bottom outlet valve handle design.

The work for converting to specification DOT-117R the tank cars involved in this accident, that were originally specification DOT-111, occurred between November 2015 and December 2018. The conversion work involved applying a ½-inch-thick ceramic fiber thermal protection blanket, adding a ½-inch-thick head shield, adding an 11 gauge jacket,

[9] A high-hazard flammable train (HHFT) means a single train transporting 20 or more loaded tank cars of a Class 3 flammable liquid in a continuous block or a single train carrying 35 or more loaded tank cars of a Class 3 flammable liquid throughout the train consist.

replacing the bottom outlet valve operating mechanism with one capable of being disengaged from the ball valve, replacing the existing top fittings protective housing with a pressure-style bolt-on ½-inch protective housing, changing the pressure relief device to a higher capacity device that activates at 75 psi, and modifying the trucks to accommodate increase in the gross rail load from 263,000 to 286,000 pounds.[10] The alterations resulted in adding 13,000 to 14,000 pounds to the tank car tare weights.

The derailed tank cars in this accident consisted of:

- 7 specification DOT-117J100W tank cars.
    - Trinity Tank Car provided certificates of construction for 4 of the derailed DOT-117J tank cars that were built to this specification as new in 2018. The heads and shells were constructed from 9/16-inch-thick AAR TC-128 Gr. B normalized steel. The stub sill underframes were type TRN 024. The tank cars were equipped with ½-inch ceramic fiber thermal protection with a thermal conductivity of 0.238 BTU-in/hr.-ft/sq.-degree F. The PRD start-to-discharge pressures were 75 psi. at 31,676 CFM flow capacity. The water capacity was about 30,300 gallons and the rail load limit was 286,000 pounds. The tank cars were equipped with full ½-inch-thick head shields. The certificate of construction states that the tank car was constructed in accordance with all applicable DOT/TC and AAR requirements, including AAR Standard S-286-2006, and MSRP C-III, Sections 2.5 and 2.7 (requirements for tank cars weighing over 263,000 lb. GRL and requirements for tank cars built for the transportation of certain flammable liquids in Packing Groups I and II).
    - Gunderson-Greenbrier provided certificates of construction for 3 of the derailed DOT-117J tank cars that were built to this specification in 2016. The heads and shells were constructed from 9/16-inch AAR TC-128 Gr. B normalized steel.[11] The stub sill underframes were type GUN001. The tank cars were equipped with ½-inch ceramic fiber thermal protection with a thermal conductivity of 0.29 BTU-in/hr.-ft/sq.-degree F. The PRD start-to-discharge pressure was 75 psi at 30,061 CFM flow capacity. The water capacity was about 30,420 gallons and the rail load limit was 286,000 pounds. The tank cars were equipped with full ½-inch-thick head shields. The certificate of construction states that the tank car meets 9 mph rollover requirements of 49 CFR 179.102-3 and top unloading protection requirements of AAR M1002, Appendix E 9.2.
- 17 specification DOT-117R100W retrofitted DOT-111 or CPC-1232 tank cars.
    - Trinity Tank Car certificates of construction for 10 of the DOT-117R tank cars that were converted from specification DOT-111, indicate they were built between 2005 and 2008. The heads were constructed of 7/16-inch-

[10] The DOT-111 tank cars that were originally constructed to CPC-1232 standards were already equipped for a gross rail load of 286,000 pounds.

[11] The material was 0.563-inch (slightly thicker than 9/16).

thick ASTM A516 Gr. 70 non-normalized steel and the tank shells were 7/16-inch-thick AAR TC-128 Gr. B non-normalized steel. The stub sill underframes were type TRN 023. The tank cars were originally provided no thermal protection, insulation, or jackets. The tanks were not lined, and their full water capacities were about 30,145 gallons. The tank cars originally had a rail load limit of 263,000 pounds.

- Trinity Tank Car certificates of construction for 3 of the DOT-117R tank cars that were converted from DOT-111 built to the industry CPC-1232 standard, indicate they were built in 2013. The heads were constructed of ½-inch-thick AAR TC-128 Gr. B normalized steel and the tank shells were ½-inch-thick AAR TC-128 Gr. B normalized steel. The tank cars originally had ½-inch-thick half-height head shields. The stub sill underframes were type TRN 024. The tank cars were originally provided no thermal protection, insulation, or jackets. The tanks were not lined, and their full water capacities were about 31,808 gallons. The tank cars originally had a rail load limit of 286,000 pounds.
- Union Tank Car certificates of construction for 4 of the DOT-117R tank cars that were converted from specification DOT-111, indicate they were built in 2007. The heads were constructed of 15/32-inch-thick ASTM A516 Gr.70 non-normalized steel and the tank shells were constructed of 7/16-inch-thick AAR TC-128 Gr. B non-normalized steel. The tank cars not originally equipped with head shields, thermal protection, insulation, or jackets. The stub sill underframes were type UTL-ZBG. The tank cars were not lined, and their water capacities were about 30,000 gallons. The tank cars originally had a rail load limit of 263,000 pounds.

- 1 specification DOT-111A100W1 tank car.
  - Trinity Tank Car provided a certificate of construction for this legacy DOT-111 tank car, which was built in 2007. The heads were constructed of 7/16-inch-thick ASTM A516 Gr. 70 non-normalized steel and the tank shell was 7/16-inch-thick AAR TC-128 Gr. B non-normalized steel. The stub sill underframes were type TRN 023. The tank car was provided no thermal protection, insulation, or jacket. The tank was not lined, its water capacity was about 30,145 gallons, and rail load limit was 263,000 pounds.

Table 4 provides a summary of tank car specifications retrieved from the UMLER report.[12]

Table 4. Derailed tank car summary

Line	Car #	Owner	Builder	Shell (in.)	Head (in.)	Insulation Thickness	Built Date[13]	DOT Spec.
82/17	TILX 199335	TILX	TRIN	0.4375	0.4375	CF, 1	12/2007	117R100W
81/18	TILX 199040	TILX	TRIN	0.4375	0.4375	CF, 1	7/2007	117R100W
80/19	TILX 191488	TILX	TRIN	0.4375	0.4375	CF, 1	8/2006	117R100W
79/20	TILX 198946	TILX	TRIN	0.4375	0.4375	CF, 1	1/2008	117R100W
78/21	TILX 194329	TILX	TRIN	0.4375	0.4375	CF, 1	11/2007	117R100W
77/22	TILX 351873	TILX	TRIN	0.5	0.5	UE	11/2013	117R100W
76/23	UTLX 209403	UTCX	UTC	0.4375	0.4688	CF, .5	10/2007	117R100W
75/24	TILX 363368	TILX	TRIN	0.5625	0.5625	CF, 1	7/2018	117J100W
74/25	TCBX 194145	SOXX	TRIN	0.4375	0.4375	none	1/2007	111A100W1
73/26	GATX 225797	GATX	TRIN	0.5625	0.5625	CF, .5	11/2018	117J100W
72/27	TILX 198738	TILX	TRIN	0.4375	0.4375		12/2007	117R100W
71/28	TILX 351793	TILX	TRIN	0.5	0.5	UE	4/2013	117R100W
70/29	FURX 160011	FURX	GMB	0.563	0.563	CF, .5	2/2016	117J100W
69/30	TILX 352058	TILX	TRIN	0.5	0.5	UE	9/2013	117R100W
68/31	TILX 363454	TILX	TRIN	0.5625	0.5625	CF, 1	7/2018	117J100W
67/32	UTLX 207573	UTCX	UTC	0.4675	0.4688	CF, .5	7/2007	117R100W
66/33	FURX 160024	FURX	GMB	0.563	0.563	CF, .5	2/2016	117J100W
65/34	UTLX 209301	UTCX	UTC	0.4375	0.4688	CF, .5	9/2007	117R100W
64/35	TILX 199078	TILX	TRIN	0.4375	0.4375		1/2008	117R100W
63/36	FURX 160030	FURX	GMB	0.563	0.563	CF, .5	2/2016	117J100W
62/37	TILX 192495	TILX	TRIN	0.4375	0.4375		9/2005	117R100W
61/38	TILX 194312	TILX	TRIN	0.4375	0.4375	CF, 1	10/2007	117R100W
60/39	TILX 363442	TILX	TRIN	0.5625	0.5625	CF, 1	7/2018	117J100W
59/40	UTLX 209496	UTCX	UTC	0.4375	0.4688	CF, .5	6/2007	117R100W
58/41	TILX 191499	TILX	TRIN	0.4375	0.4375	CF, 1	8/2006	117R100W
57/42	TILX 199062	TILX	TRIN	0.4375	0.4375	CF, 1	1/2008	117R100W

Breached Tank Car
DOT-117J
Retrofitted CPC-1232
Retrofitted DOT-111
Legacy DOT-111

ATTACHMENT 11 – CERTIFICATES OF CONSTRUCTION, AAR FORMS 4-2, TANK CARS BUILT BY TRINITY INDUSTRIES, INC. AND BY TRINITY TANK CAR, INC.

[12] Many tank car specification plates were oxidized and obliterated following the derailment.
[13] Original date of construction.

ATTACHMENT 12 – CERTIFICATES OF CONSTRUCTION, AAR FORMS 4-2, TANK CARS BUILT BY UNION TANK CAR COMPANY
ATTACHMENT 13 – CERTIFICATE OF CONSTRUCTION, AAR FORM 4-2, TANK CARS BUILT BY GUNDERSON

ATTACHMENT 14 – TRINITY TANK CAR EXHIBIT R-1 REPORT OF TANK REPAIRS, ALTERATION, OR CONVERSION, JANUARY 4, 2019
ATTACHMENT 15 – EXCERPT OF UNION TANK CAR COMPANY RETROFIT CONVERSION INSTRUCTIONS, NOVEMBER 28, 2017
ATTACHMENT 16 – AUTOMATIC EQUIPMENT IDENTIFICATION REPORT, APRIL 23, 2019

I. Breached Tank Car Details

Derailment Damage Summary

On July 9 – 10, 2019, NTSB investigators and parties to the investigation (Hazardous Materials Group) inspected the derailed tank car wreckage that had been staged in a field immediately adjacent to the accident scene. See Appendix A for additional damage assessment details. Table 5 summarizes the tank car damages that occurred in this accident.

Table 5. Tank car derailment damage summary.

UPRR Derailment
Fort Worth TX
4/24/2019
Cargill Ethanol Unit Train

Total Cars Derailed	26
Identified Cars Total	26
Inspected Car Total	26

Defect Description	NO	YES	Percentage of Failure
Manway Compromised	25	1	4%
Multihousing Compromised	24	2	8%
Valves Damaged	25	1	4%
Skid Damaged	23	3	12%
BOV Adaptor Sheared	16	10	38%
BOV Open	25	1	4%
BOV Handle Damaged	11	15	58%
Dis-Engageable BOV Handle	1	25	96%
Thermal Tear	26	0	0%
Mech Tear	23	3	12%
Draft sill torn off A End	25	1	4%
Draft sill torn off B End	23	3	12%
Head Brace pulled from head pad	26	0	0%
Head pad pulled from tank	26	0	0%
Body Bolster pulled from pad	24	2	8%
Bolster Pad pulled from tank	24	2	8%
Tank Breaches Identified	23	3	12%

Three of the derailed tank cars released ethanol in this accident: UTLX 209403, TCBX 194145, and UTLX 209301. The breaching damage and service histories of these tank cars are further described below.

(23/76) UTLX 209403

- Shell tear, 6 x 13-inches, across the B-L body bolster pad. The bolster was bent flat to the tank toward the A-end and appears to have shell material adhering to the weld attachment that was torn away from the tank (Figure 4).
- Top fittings multihousing protective cover was sheared from the flange and the liquid, vapor, vacuum relief valves, and a blind flange were broken away leaving four openings into the tank. The flange and surrounding tank jacket showed evidence of thermal damage. Shear pattern on the bolts show the impact came from the B-end direction. A dent and jacket tear also occurred on the opposite, A-end side of the flange (Figure 5).
- UP contractors confirmed that 27,290 gallons of ethanol were released from this tank car, while about 1,489 gallons were recovered.

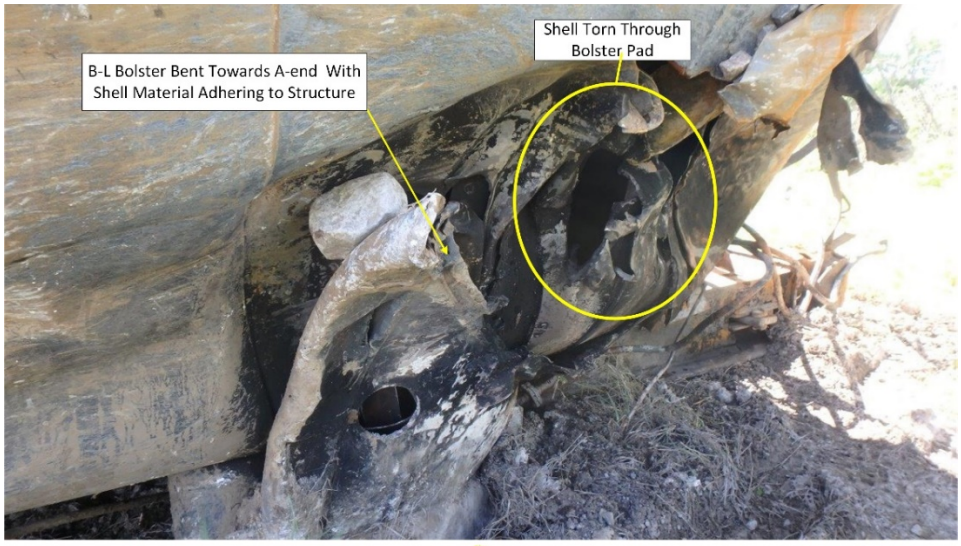


Figure 4. Shell tear, 6 x 13-inches, B-L bolster pad area

Figure 5. Top fittings flange showing missing multihousing cover, vapor valve, liquid valve, and VRV. A dent and jacket tear occurred on the opposite side of the flange (circled).

(25/74) TCBX 194145

- Left side shell tear, 86 x 255-inches (Figure 6).
- B-end head punctured (Figure 7).
- Bottom outlet ball valve was open, handle was manipulated downward in the derailment.
- The tank car released its total load, about 28,779 gallons of ethanol.

Figure 6. TCBX 194145, left side shell tear.

Figure 7. TCBX 194145, B-end head punctures and dents.

(34/65) UTLX 209301

- The left side of the car was impacted near center, resulting in a 2-inch diameter hole. The jacket was gouged about 19-inches wide toward the A-end about 13-feet (Figures 8 and 9).
- The tank had 44-inches of outage and released about 9,112 gallons of ethanol.

Figure 8. Dent and jacket damage to left of tank puncture.

Figure 9. UTLX 209301, 2-inch diameter hole in tank shell.

Breached Tank Car Service Histories

(23) UTLX 209403

The tank car had initially been in ethanol service between October 2007 and July 2009, with 46,595 miles. The car was in storage with residue of ethanol between August 2009 and October 2009. Between October 2009 and April 2016, the tank car was used in crude oil service, logging 457,488 miles. Since June 2016, Cargill had used the tank car in ethanol transportation, logging 125,122 miles.

(25) TCBX 194145

According to the tank car owner, SMBC Rail Services, LLC, the tank car had been in ethanol service for its entire service life (since January 2007).

(34) UTLX 209301

The tank car had initially been in ethanol service between September 2007 and January 2009, with 57,403 miles. The car was in storage with residue of ethanol between February 2009 and July 2010. Between July 2010 and April 2016, the tank car was used in crude oil service, logging 295,043 miles. Since June 2016, Cargill had used the tank car in ethanol transportation, logging 120,077 miles.

Qualification, Maintenance, and Conversions

(23) UTLX 209403 and (34) UTLX 209301

In 2016, Union Tank Car Company (station stencil UTCO, Marion, Ohio) performed required inspections for both tank cars, including tank qualification, thickness test, service equipment, PRD, 88b inspection, and stub sill inspections. At the same time, Union Tank Car performed HM-251 conversions to bring the tank cars into conformance with Specification DOT-117R.

The head brace and draft weld and bolster pad weld visual inspections found no indications that required repair. Likewise, the bottom outlet valve saddle, sump, and skid welds were free of any visual indications. Union Tank Car reported that structural integrity inspections using ultrasonic thickness, magnetic particle, and direct visual inspection methods found no cracks or anomalies in the interior or exterior tank heads and shell, stub sill, and other structural components.

The tank corrosion inspection reports for both tank cars indicated the interior tank surfaces were uniformly "roughened" by corrosion. For both tanks, the tank inspector commented "rust bloom throughout." However, the inspector reported there were no areas below the minimum corrosion allowance thickness that Union Tank Car determined was appropriate for these cars in accordance with 49 CFR Part 180.509(f) and (g) (Figure 10). Measured shell thickness at 3 o'clock and 6 o'clock (middle and bottom near each circumferential tank ring butt weld) for UTLX 209301 were no less than 0.450-inch and for UTLX 209403 no less than 0.446 inch.[14]

Minimum Allowable Thickness

Uniform Corrosion Minimum Allowable Thickness

Top Shell:	0.313	Bottom Shell:	0.375
Tank Head:	0.313		

Local Corrosion Minimum Allowable

Top Shell:	0.250	Bottom Shell:	0.313
Tank Head:	0.250		

Figure 10. Union Tank Car Company corrosion allowance minimum head and shell thicknesses for UTLX 209301 and UTLX 209403.

[14] The approved design shell thickness was 7/16, or 0.4375-inch. Union Tank Car told NTSB investigators that its mill-spec reports show the shell plate from which the tanks were fabricated exceeded the certificate of construction thicknesses requirements; thus, it is possible to measure shell thicknesses in excess of 7/16-inch, even when the material had been subjected to corrosion.

After the inspections were completed and prior to returning the cars to service, Union Tank Car grit-blasted the rust scale from interior surfaces of the tanks (Figure 11). Cargill leased these tank cars and placed them in ethanol service immediately following their qualification inspections and conversions to DOT-117R.

Figure 11. Before and after grit blasting. Views of the interior surface of UTLX 209301 during the 2016 shopping for qualification inspection, courtesy of Union Tank Car Company.

(25) TCBX 194145

On February 21, 2017, the Rescar Companies tank car facility located in Savanna, Illinois, conducted a tank qualification, thickness test, service equipment inspection, PRD test, AAR Rule 88.B.2 inspection, and stub sill inspection for tank car TCBX 194145, on behalf of its owner, SMBC.[15] The Rescar inspector found that the A-R head pad-to-tank weld did not have complete fusion in two locations and that these defects were removed with grinding without the need to weld. The inspector also noted that the BOV cap was leaking. The inspector found no other structural integrity defects on the tank that required repair and after the aforementioned items were corrected. The inspector passed all final inspection and test items with no exceptions.

The SMBC maintenance advisory contractor, Alltranstek, provided minimum shell thickness for corrosion allowance of 0.3125-inch top and 0.375-inch bottom. During the 2017 inspection, all Rescar shell thickness measurements exceeded 0.452-inch bottom shell, 0.445-inch top shell, and 0.542-inch for the tank heads.

[15] The Association of American Railroads *Field Manual of the AAR Interchange Rules*, Rule 88.B.2 requires periodic inspections of the tank car's trucks, body bolsters and center plates, center sills, crossbearers, crossties, end sills, side sills, and draft gear components.

Postaccident Ultrasonic Thickness Inspections

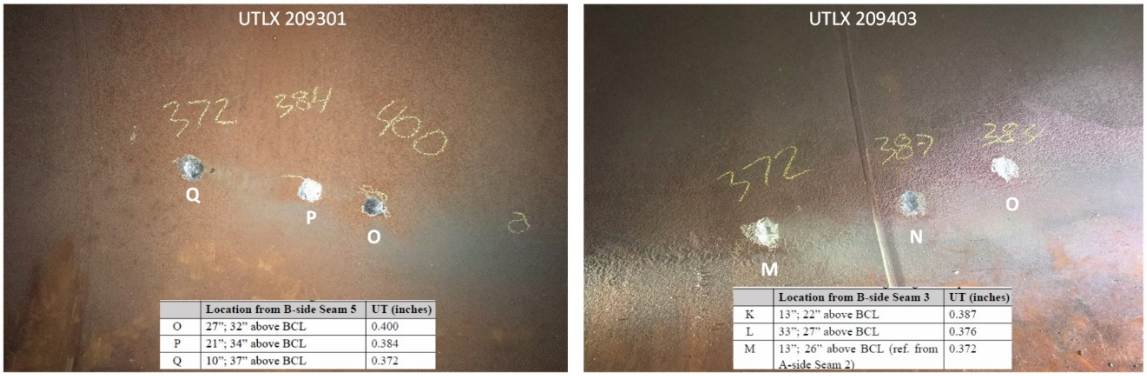
On, June 18, 2019, after UP had contractors purge and clean the tank cars of ethanol, investigators returned to the staging area in Fort Worth to further inspect tank cars of interest that had been dejacketed for closer inspection and to remove tank coupons for detailed examinations. Investigators noticed that two of the breached tank cars (23) UTLX 209403 and (34) UTLX 209301 exhibited evidence of internal corrosion that was not observed in several other accident tank cars. This prompted some of the Hazardous Materials group reconvene at the Fort Worth to conduct ultrasonic thickness measurements to determine whether corrosion may have exceeded minimum shell thickness requirements.

A Union Tank Car Level II NDT technician inspected both cars with the Group, examining the thickness for Union's standard ultrasonic thickness pattern for the lower portions of the heads and tank shells (3 o'clock and 6 o'clock on both sides of circumferential butt welds, and the center and 3 o'clock on the heads).[16] This was done to replicate the examination that was given the two tanks in 2016 for determining corrosion rates, if any. For UTLX 209403, the thinnest shell measurement was 0.441-inch; for the heads was 0.470-inch. For UTLX 209301, the thinnest shell measurement was 0.443-inch; for the heads was 0.471-inch.

In addition, the Group identified several locations in each tank for ultrasonic testing where the most visible corrosion occurred. The technician removed surface rust and scale at the test locations with a grinding wheel to ensure that useable shell thickness was being measured. These spot measurements found numerous thinner locations than measured at the standard tank pattern locations, however in all cases the material thicknesses exceeded minimum values Union Tank Car had specified for the tanks; 0.375-inch for the shell bottom, 0.313-inch for the shell top, and 0.313-inch for the head.[17] The minimum shell thickness measurement the technician identified for UTLX 209301 was 0.372-inch at one location in the shell Ring 4 above the tank bottom. For UTLX 209403, the minimum shell thickness measured was 0.372-inch at one location in shell Ring 2 above the shell bottom (Figure 12). The technician rated the thickness test for both tank cars as acceptable.

[16] The American Society for Nondestructive Testing administers the Level II certification program and qualification standards. Recommended Practice No. SNT-TC-1A establishes the general framework for a qualification and certification program. In addition, the document provides recommended educational, experience and training requirements for the different test methods.

[17] The shell bottom is defined by 49 CFR 171.8 as 24-inches to either side of the bottom longitudinal center line. Union Tank Car determined the minimum allowable head and shell thicknesses in accordance with 49 CFR 180.509(g).



	Location from B-side Seam 5	UT (inches)
O	27"; 32" above BCL	0.400
P	21"; 34" above BCL	0.384
Q	10"; 37" above BCL	0.372

	Location from B-side Seam 3	UT (inches)
K	13"; 22" above BCL	0.387
L	33"; 27" above BCL	0.376
M	13"; 26" above BCL (ref. from A-side Seam 2)	0.372

Figure 12. Minimum shell thickness locations and examples of corrosion observed in tank cars UTLX 209301 and UTLX 209403 during the June 18, 2019, ultrasonic thickness inspections.

Collected Tank Car Evidence to be Examined

The Hazardous Materials Group shipped the following items to the NTSB Office of Research and Engineering for additional examinations:

- (34)UTLX 209301 reference shell plate coupon from the right-center side of Ring 2
- (34)UTLX 209301 shell plate with approx. 2" diameter puncture from left-center side of Ring 2
- (36)FURX 160030 Handbrake wheel, nut, and surrounding B-end head shield plate
- (23)UTLX 209403 breached shell plate with B-L body bolster pad and bent bolster web.

The examination plan will include laser scanning the UTLX 209301 shell plate puncture area and comparing the hole with the geometry of the suspected puncturing object, the FURX 160030 brake wheel nut. In addition, the breached shell plate thickness is to be mapped and examined for voids, cracking, and corrosion in the breached area. The reference shell plate will be subjected to tensile and chemical testing for comparison with standards for AAR TC-128 gr. B steel.

For the UTLX 209403 breached shell plate and bolster section, the examination will include fillet weld thickness compared to tank drawings and AAR specifications for tank cars. The examination will also note the presence of any cracks, voids, corrosion, weld or metallurgical features of interest to explain the likely breaching mechanism.

ATTACHMENT 17 – TANK CAR DAMAGE ASSESSMENT NOTES, APRIL 25-29, 2019
ATTACHMENT 18 – DERAILMENT DAMAGE SUMMARY SPREADSHEET
ATTACHMENT 19 – SUPPLEMENTAL FRA TANK CAR INSPECTIONS, MAY 20, 2019
ATTACHMENT 20 – UNION TANK CAR COMPANY QUALIFICATION INSPECTION AND TEST REPORT FOR UTLX 209301, JUNE 6, 2016

ATTACHMENT 21 – UNION TANK CAR COMPANY QUALIFICATION INSPECTION AND TEST REPORT FOR UTLX 209403, JUNE 2, 2016
ATTACHMENT 22 – RESCAR COMPANIES QUALIFICATION INSPECTION AND TEST REPORT FOR TCBX 194145, FEBRUARY 21, 2017
ATTACHMENT 23 – UNION TANK CAR COMPANY UTT REPORTS FOR UTLX 209301 AND UTLX 209403, JUNE 18, 2019
ATTACHMENT 24 – REQUEST FOR MATERIALS LABORATORY EXAMINATION, UTLX 209301 AND FURX 160030, JUNE 26, 2019
ATTACHMENT 25 – REQUEST FOR MATERIALS LABORATORY EXAMINATION, UTLX 209403, JUNE 26, 2019

J. Previous Accidents

DOT-117 Tank Cars

Comparable accidents involving specification 117 tank cars include the June 22, 2018, derailment of a BNSF Railway unit train in Doon, Iowa, in which 33 DOT-117R tank cars derailed and released 160,000 gallons of crude oil into a tributary of the Rock River. Ten of the derailed tank cars were breached because of punctures to tank heads and shells and valve or fitting damages. The Doon, Iowa accident was the first mainline derailment involving significant numbers of specification DOT-117R tank cars. Additional information about the Doon, Iowa accident is available in the NTSB docket for this investigation.[18]

Two additional accidents involving DOT-117 tank car accidents occurred on April 30, 2017, in Money, Mississippi, and on February 16, 2019, in St. Lazare, Manitoba.

The Money, MS incident involved one DOT-117 near the rear of a standing Canadian National Railway crude oil unit train that was impacted by a CPC-1232 tank car after being struck by another CN freight train.[19] The DOT-117 tank car did not release any hazardous material.

The only other mainline derailment involving DOT-117R tank cars occurred when a Canadian National crude oil unit train traveling at 49 mph derailed 37 tank cars, breaching at least 14 tank cars and releasing about 217,000 gallons of product.[20]

[18] See *DOT-117R Tank Car Performance Factual Report* and attachments contained in NTSB docket HMD18LR002.
[19] See *Materials Laboratory Factual Report 17-046* contained in NTSB docket DCA17SH002
[20] See Transportation Safety Board of Canada website for railway investigation R19W0050 for further details at http://www.bst-tsb.gc.ca/eng/enquetes-investigations/rail/2019/r19w0050/r19w0050.asp

Bottom Outlet Valve Incidents

The NTSB has found instances of bottom outlet valve handles being bent or pulled away from their securement brackets during derailments, thus causing the ball valves to unseat and release lading.[21] In these cases, operating handles had been manipulated to the open position by derailment forces and once a bottom outlet nozzle had been sheared off, there was nothing to prevent product from releasing. Thus, the NTSB noted that previous designs employed on DOT-111 and CPC-1232 tank cars did not ensure that the BOV would remain closed if the handle failed to break free when impacted in an accident. Following the June 19, 2009 derailment of a Canadian National Railway freight train in Cherry Valley, Illinois, the NTSB was prompted to issue Safety Recommendation R-12-006 to the PHMSA:

> Require that all bottom outlet valves used on newly manufactured and existing non-pressure tank cars are designed to remain closed during accidents in which the valve and operating handle are subjected to impact forces.

On July 12, 2016, the NTSB classified Safety Recommendation R-12-006 as closed with acceptable action following the issuance of PHMSA final rule HM-251 that requires bottom outlet valve protection for the DOT-117 tank car, including performance and retrofit standards in sections 179.202-8, 179.202-12(e), and 179.202-13(g), specifically that all bottom outlet handles must either be removed or designed to prevent unintended actuation during derailment scenarios.

The PHMSA Hazardous Materials Incident Report (Form 5800.1) database does not include cause codes specific to releases related to the failure of the bottom outlet valve handle operating mechanism to prevent the valve from opening in a derailment.

In 2006, Railway Supply Institute Railroad Tank Car Safety Research and Test Project (Safety Project) published a report on the probabilities of lading loss from tank cars based on its data set of tank cars damaged in accidents prior to 1996.[22] The report considered the effect of various design parameters on tank car accident performance. The Safety Project reported that for a mainline derailment of 7/16-inch thick jacketed non-pressure tank cars

[21] National Transportation Safety Board, Derailment of CN Freight Train U70691-18 With Subsequent Hazardous Materials Release and Fire, Cherry Valley, Illinois, June 19, 2009, RAR-12/01 (Washington DC: National Transportation Safety Board, 2012).

[22] *Safety Performance of Tank Cars in Accidents: Probabilities of Lading Loss*, Report Number RA 05-02 (Leesburg, VA., RSI-AAR Railroad Tank Car Safety Research and Test Project, 2006).

with full head shield and bottom fittings, the estimated overall lading loss probability is 18.79 percent, with an individual lading loss probability of 4.46 percent attributable to bottom fittings damage.[23]

Paul L. Stancil, CHMM
Sr. Hazmat Accident Investigator

[23] The RSI reports that the probability for an entire car is lower than the sum of the four component probabilities, because loss sources are not mutually exclusive.

Appendix A: Tank Car Examination Data

Tables A-1 through A-40 summarize field observations collected for the derailed tank cars.

Key to abbreviations used in this Appendix

B-end: the end of the car with the handbrake wheel
A-end: the end of the car opposite the B-end
A-L: A-end, left side
A-R: A-end, right side
B-L: B-end, left side
B-R: B-end, right side
BOV: bottom outlet valve
PRD: pressure relief device
Top Shell: 2-feet to the right and left of the top longitudinal centerline [24]
Bottom Shell: 2-feet to the right and left of the bottom longitudinal centerline
Trans.: Transverse, or circumferential direction.
Long.: Longitudinal direction.

All observations and orientations provided are from the perspective of facing the B-end of the tank car.

To provide an understanding of tank car damage context, Figures 13 - 15 show the breached tank cars in-situ and provide orientation marks for the original train configuration and leading tank ends.

[24] For the purpose of this appendix, the term *Top Shell* is different from the definition provided in 49 CFR 171.8, which includes all shell surfaces other than the *Bottom Shell*.

Figure 13. South end (head) of the derailment. Leading ends are labeled.

Figure 14. Middle of the derailment. Leading ends are labeled.

Figure 45. North end (rear) of the derailment. Leading ends are labeled.

Table A-1: Tank Car TILX 191488[25]

Consist order	19 (80)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest upside-down on its upper left side. The car was parallel to the track on west side of the right-of-way at the south (leading) end of the pileup. The B-end facing south (Figure 15).
Heads	The A-end had a 3'x4'dent, 12" deep, upper left center.
Shell	The A-R side jacket paint was thermally damaged, from the car center to the A-end. The left side was covered with drag marks and jacket wrinkling end to end.
Bottom outlet valve	The BOV nozzle and operating handle were not damaged.
Top fittings, PRD and Manway	The top fittings protective housing, manway, and PRD were caked in mud. The PRD did not function.
Stub sills and couplers	The B-end draft sill was bent about 15 degrees upward.
Other	No commodity loss.

1(a) A-end head dent, 3'x4'

1(b) Top fittings caked in mud.

1(c) Thermal damage right side, center to A-end.

2(d) Left side ground surface contact area.

[25] Leading tank cars TILX 199335 (position 17) and TILX 199040 (position 18) were re-railed and removed from the accident scene. These tank cars did not exhibit significant derailment damage and were not inspected.

Table A-2: Tank Car TILX 198946

Consist order	20 (79)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest on its right side, parallel the direction of travel and parallel to UTLX 209403 on the west side of the right-of-way. The A-end was facing south (Figure 15).
Heads	The A-end head sustained a 1' x 2' dent about 10 o'clock.
Shell	The right-side tank jacket was scraped, wrinkled, and covered in mud.
Bottom outlet valve	The BOV area was impinged by flame from damaged top fittings of adjacent car UTLX 209403, although thermal damage was not evident. The BOV nozzle was not damaged. The operating handle sleeve was bent and was in contact with the BOV extension shaft.
Top fittings, PRD and Manway	The top fittings were caked in mud but were not mechanically damaged.
Stub sills and couplers	The B-end stub sill was bent about 60 degrees to the right.
Other	Both A-R and B-R bolsters were bent about 45-degrees toward the B-end. No commodity loss.

2(a) B-end head bent stub sill, right side shell with wrinkled jacket and scrapes.

2(b) A-end head with dent at 10 o'clock.

2(c) BOV operating handle and undamaged nozzle.

2(d) Bent BOV operating handle shaft and extension.

Table A-3: Tank Car TILX 194329

Consist order	21(78)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest on its left side, parallel the direction of travel and parallel to TILX 363368 on the west side of the right-of-way. The B-end was facing south (Figure 15).
Heads	The A-end head sustained a sharp gouge about 5 o'clock. The head shield was not punctured.
Shell	The left side jacket was wrinkled and scraped end-to-end.
Bottom outlet valve	The top fittings protective housing of TILX 363368 was in contact with the BOV area in the pileup. The BOV operating handle was missing, the nozzle was not damaged.
Top fittings, PRD and Manway	The top fittings were covered in mud and vegetation.
Stub sills and couplers	The B-end stub sill was torn off at the head brace.
Other	A-L and B-L bolsters were bent about 15 degrees toward the A-end. No commodity loss.

3(a) B-end head and left side.

3(b) A-end head gouge at 5 o'clock.

3(c) Top fittings, left side.

3(d) BOV missing operating handle and undamaged nozzle.

Table A-4: Tank Car TILX 351873

Consist order	22 (77)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest on its left side, parallel the direction of travel on the west side of the right-of-way. The B-end was facing south. The B-end head of TCBX 194145 was in contact with the B-end bottom, and the A-end of GATX 225797 was in contact with the A-end head (Figure 16).
Heads	A-end head shield was dented 1'x3' at 12 o'clock, and 1'x1' at 11 o'clock.
Shell	Thermal damage to jacket paint on bottom, end to end. Jacket was torn from B-L bottom to A-L bottom, with underlying shell dent and gouges.
Bottom outlet valve	BOV nozzle was missing. The operating handle was bent and offset from BOV stem. The BOV face was covered with soot and remained closed.
Top fittings, PRD and Manway	The right side of the top fittings protective housing was abraded. There were no fittings damages.
Stub sills and couplers	B-end coupler was fractured from shank and the striker plate was wedged into the A-L shell of GATX 225797. A-end coupler was missing, and draft sill was twisted to right a couple of inches.
Other	A-R and A-L bolsters were bent 45-degrees toward the A-end. Photoionization detector measured 176 ppm VOC near the BOV, but no visible commodity loss.

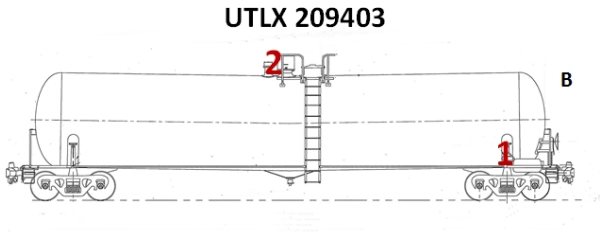
4(a). Tank bottom as found in the accident scene, showing thermal damage, with jacket tear and dent on B-L bottom.

4(b) A-end head shield dents at 11 and 12 o'clock.

4(c) A-end and left side, bent A-L body bolster.

6(d) Thermally damaged BOV with missing nozzle.

Table A-5: Tank Car UTLX 209403

Consist order	23 (76)
Specification/builder	DOT-117R100W, Union Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest on its left side, parallel the direction of travel on the west side of the right-of-way. The B-end was facing south. The car was laying between the track and TILX 198946. Fire from the top fittings flange was impinging on the bottom of TILX 198946 (Figure 15).
Heads	Deep dent 11-12 o'clock on the B-end head extended into the B-end top shell, measured 27" deep x 42" wide x 72" long. A deep dent at 7 o'clock on the B-end head extended into the B-L shell and bolster area. The A-end head shield had partially separated in the accident scene but was later torn off during wreckage handling.
Shell	**1. Breaching damage:** Shell tear, 6 x 13-inches, across the B-L body bolster pad. The bolster was bent flat to the tank toward the A-end and appears to have shell material adhering to the weld attachment that was torn away from the tank. Other damage: The top surface jacket paint was thermally damaged end-to-end.
Bottom outlet valve	The BOV nozzle and operating handle were missing. The BOV remained closed.
Top fittings, PRD and Manway	**2. Breaching damage:** The multihousing protective cover was sheared away from the top fittings flange and the liquid, vapor, and vacuum relief valves, and blind flange were broken away leaving four openings into the tank. The flange and surrounding tank jacket showed evidence of thermal damage. Shear pattern on the bolts suggest the impact came from the B-end direction. A dent and jacket tear occurred on the opposite, A-end side of the flange. Other damage: Two of the six manway swing bolts were broken.
Stub sills and couplers	
Other	 *Breaching damage locations* About 27,290 gallons of ethanol released from this tank car, 1,489 gallons were recovered.

5(a) Car in the derailment scene on its left side with fire from top fittings impinging on adjacent car TILX 198946.

5(b) B-end head dent at 7 o'clock and breach to tank shell where the B-L bolster pad had been attached.

5(c) Fractured tank shell in B-R bolster region.

5(d) Deep B-end head dents at 11 – 12 o'clock.

5(e) Top fittings flange with missing protective housing, liquid, vapor, and vacuum relief valves.

5(f) B-top jacket tear and dent 27" deep x 42" wide x 72 long.

Table A-6: Tank Car TILX 363368

Consist order	24 (75)
Specification/builder	DOT-117J100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest on its right side, parallel the direction of travel on the west side of the right-of-way. The A-end was facing south. The car was laying between the track and TILX 194329 (Figure 15).
Heads	B-end head shield separated and hanging loose from the head. The B-end head shield sustained a 2' x 2' rounded dent about 4 o'clock.
Shell	A gouge 116" long, about 2" wide, and several inches deep ran from almost the B-end head down the center of the B-R side. A large section of jacket was torn away from the B-R side. The gouge continued over jacket down the length of the center-left side. The B-end top to B-R jacket and shell was creased about 1'ft deep
Bottom outlet valve	The BOV nozzle and operating handle were missing.
Top fittings, PRD and Manway	
Stub sills and couplers	B-end coupler was fractured and missing, with the right side of the draft sill torn 10-inches inboard from the striker plate.
Other	The B-R bolster was bent 90-degrees toward the B-end. The bolster pad did not separate from the shell. No commodity loss.

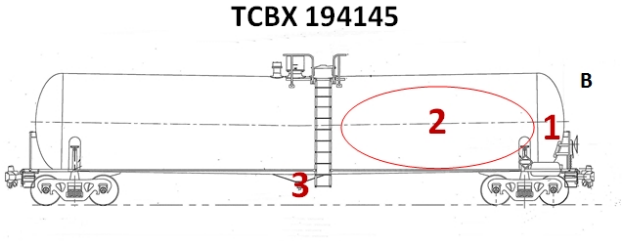
8(a) B-R side jacket tear and gouge. The gouge continued over jacket down the center left side.

8(b) B-R gouge 116-inches in length, 2-inches wide.

8(c) B-end head, with partially detached head shield.

8(d) B-R bolster bent toward the B-end.

Table A-7: Tank Car TCBX 194145

Consist order	25 (74)
Specification/builder	DOT-111A100W1, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular across the right-of-way and upright, with its B-end facing west. The B-end was in contact with B-end bottom of TILX 351873 (Figure 16).
Heads	**1. Breaching damage:** Rectangular puncture, about 2"x6" near 9:00 on B-end head, within circular dents above and below the puncture. The B-end head was torn from 8 – 10 o'clock, with the breach continuing into the B-L shell.
Shell	**2. Breaching damage:** The B-L shell was torn 86" wide (at widest part) and 255" long from the B-end head to the center ladder. The fracture surfaces were irregular in shape, with sawtooth burrs on the bottom fracture surface. The breach terminated into a 4-inch narrower channel with peeled-back shell material. A piece of rolled shell steel was found in the bottom of the tank, which fit into this channel. Other damage: The B-R side was buckled from bottom to top. The B-end and half of the A-end shell was thermally damaged.
Bottom outlet valve	**3. Breaching Damage:** The BOV nozzle was missing and the ball valve was about 2/3 open. There BOV operating handle was bent about 90 degrees downward (not a retrofitted BOV operating handle). Other damage: The B-side of the BOV skid protection structure fillet weld was torn from the tank bottom reinforcement plate, leaving the structure touching the right side of the BOV saddle.
Top fittings, PRD and Manway	Top side thermal damage included the top fittings housing, manway, and PRD.
Stub sills and couplers	
Other	 *Breaching damage locations.* About 28,779 gallons (full load) of ethanol released from this tank car.

7(a) Car in the derailment scene showing the B-L irregular-shaped shell tear.

7(b) Inboard B-L shell tear detail.

7(c) Bottom B-end shell breach with high-rate tearing fracture (sawtooth burrs) on bottom fracture surface.

7(d) B-end head rectangular puncture and tear.

7(e) B-end head breaching damage.

7(f) Buckled B-R side and thermal damage.

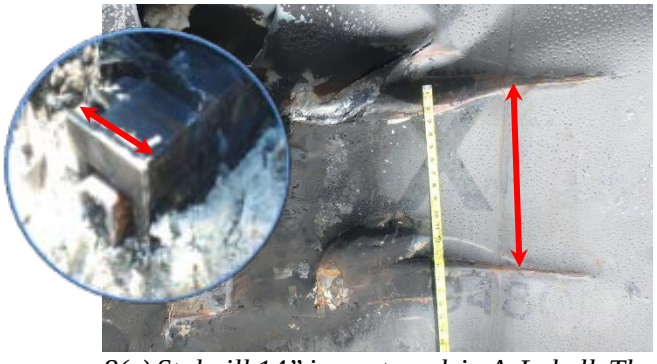
7(g) Open BOV ball valve, bent operating handle and fractured skid weld.

Table A-8: Tank Car GATX 225797

Consist order	26(73)
Specification/builder	DOT-117J100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular across the right-of-way and upright, with its B-end facing east. The B-end was in contact with B-end stub sill of TILX 351873 (Figure 16).
Heads	
Shell	The A-L shell was deeply dented and gouged 14" wide in center, by contact with the stub sill striker plate of TILX 351873. The gouge terminated into a 24" circumferential jacket tear. A-L jacket paint was thermally damaged.
Bottom outlet valve	BOV nozzle sheared off the flange. The BOV operating handle was bent, but the ball valve remained closed.
Top fittings, PRD and Manway	
Stub sills and couplers	The A-end stub sill head brace-to-head pad transverse fillet weld fractured, and the stub sill was bent 45 degrees toward the left. The head pad remained attached.
Other	The A-L bolster was bent 45 degrees toward the A-end and the upper bolster pad was torn from the tank at the lifting lug, fracturing the fillet weld with no crack in parent metal (wrecking damage?). No commodity loss.

8(a) A-end stub sill of TILX 351873 wedged into the A-L shell as found in the derailment site.

8(b) A-end impact location as seen in the staging area. Thermal damage to jacket paint.

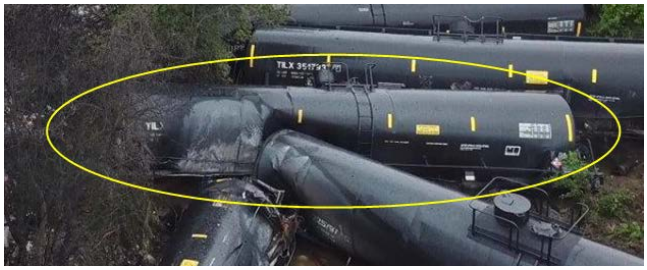


8(c) Stub sill 14" impact mark in A-L shell. The tank jacket is still in place. Inset photo is the stub sill of TILX 351873 showing relationship of impact mark to contact surface.

8(d) A-L shell after jacket removal showing non-penetrating gouge and dent left by the impacting stub sill. A-L bolster pad torn from the tank.

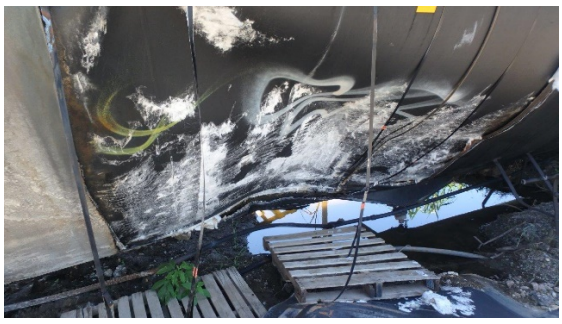
Table A-9: Tank Car TILX 198738

Consist order	27 (72)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest perpendicular across the right-of-way, leaning to the right with its A-end facing west and extending into property bordering the right-of-way. The B-end of GATX 225797 was in contact with the A-L side (Figure 17).
Heads	The A-end head shield sustained a 2" x 8" puncture within a dent at the 5 o'clock edge. The puncturing object did not contact the underlying tank head. Jacket was buckled between the A-end head and tank shell. The B-end head sustained a rounded dent 3' x 5' and 8" deep in the upper right quadrant.
Shell	The A-L shell was buckled 69" deep and half the diameter of the car. Jacket was thermally damaged from the buckle to the A-end head. No crack was found after jacket removal and reinspection.
Bottom outlet valve	The BOV nozzle sheared from the flange and was hanging by its chain and the operating handle was missing. The BOV was found dripping ethanol in the staging area, photoionization detector measured 462.8 ppm VOC and 12% LEL near the BOV. Contractors repositioned the valve ball and the leak stopped (unknown if leak began during movement to staging area).
Top fittings, PRD and Manway	
Stub sills and couplers	
Other	Full load was recovered from the tank, and remediation contractor reported the tank was relieved pressure upon opening to pump out. No commodity loss.



9(a) Resting position in the derailment scene with B-end of GATX 225797 in contact with the A-L shell.

9(b) Buckled A-L shell and thermal damage to jacket.



9(c) Buckled A-L shell after jacket removal, no crack found.

9(d) A-end head shield with 2" x 8" puncture.

Table A-10: Tank Car TILX 351793

Consist order	28 (71)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular across the right-of-way, leaning to the right with its leading B-end facing east (Figure 17).
Heads	The A-end head shield was deeply gouged with two parallel marks from the 10 o'clock edge toward center, and at 6 o'clock above the stub sill. Gouges did not penetrate the head shield.
Shell	The B-L bottom shell was dented 2' x 3', about 5" deep.
Bottom outlet valve	BOV nozzle was not damaged and the operating handle was buried in soil.
Top fittings, PRD and Manway	
Stub sills and couplers	
Other	B-R and B-L bolsters were bent 90 degrees toward A-end. The tank was lined with 2900 LV, applied by SRCO 5/2013. No commodity loss.

10(a) A-end head shield gouges about 10 o'clock.

10(b) A-end and right side.

10(c) A-end head shield gouge about 6 o'clock.

10(d) B-end head and left side.

Table A-11: Tank Car FURX 160011

Consist order	29 (70)
Specification/builder	DOT-117J100W, Gunderson
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest upright and perpendicular across the right-of-way, with its A-end facing west (Figure 17).
Heads	The A-end head sustained a 5" deep dent with a gouge from the 5 o'clock edge, horizontally across the head shield toward the center.
Shell	The A-L shell was dented 7' (trans.) x 8' (long.) and 15" deep
Bottom outlet valve	The BOV operating handle sleeve was deflected away from the ball valve extension shaft. The BOV nozzle sheared from the flange.
Top fittings, PRD and Manway	
Stub sills and couplers	B-end draft sill bent a few inches toward the right.
Other	No commodity loss.

11(a) A-end head shield and gouge at 5-6 o'clock.

11(b) A-L shell dent, 7'x8', 15" deep.

11(c) BOV operating handle separated from the ball valve extension shaft.

11(d) B-end head and right side.

Table A-12: Tank Car TILX 352058

Consist order	30 (69)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular across the right-of-way and leaning on its left side. The B-end was facing east (Figure 17).
Heads	
Shell	The A-L jacket was torn about 2-ft. circumferentially. The B-L jacket sustained a 3'x 5'dent. An impacting object tore the B-L bottom jacket material and deeply gouged the tank shell. The B-L bottom jacket below the impact mark was torn longitudinally about 2-feet.
Bottom outlet valve	BOV nozzle was undamaged, operating handle was bent upward and was detached from the ball valve extension. The left skid protection side plate was fractured in center.
Top fittings, PRD and Manway	
Stub sills and couplers	The A-end stub sill was bent a few inches to the right.
Other	Lining – S/W Nova Plate, applied TXXV 10/2013, qualified 2016. A-R bolster bent toward B-end about 15 degrees. B-R bolster bent toward B-head about 45 degrees. No commodity loss.

12(a) B-end head and B-L jacket dent.

12(b)B-L jacket tear and non-breaching shell gouge.

12(c) B-L longitudinal jacket tear below shell gouge.

12(d) The BOV operating handle sleeve was bent away from the ball valve extension.

Table A-13: Tank Car TILX 363454

Consist order	31 (68)
Specification/builder	DOT-117J100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest upright and perpendicular across the right-of-way, with its A-end facing west (Figure 17).
Heads	
Shell	
Bottom outlet valve	The BOV nozzle was missing, the operating handle was bent away from the ball valve extension.
Top fittings, PRD and Manway	
Stub sills and couplers	
Other	No commodity loss.

13(a) Left side and B-end head.

13(b) Right side, jacket wrinkles and scratches.

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13(c) B-end head.

13(d) The BOV operating handle sleeve bent away from ball valve extension.

Table A-14: Tank Car UTLX 207573

Consist order	32 (67)
Specification/builder	DOT-117R100W, Union Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular to the direction of travel and upright with the B-end facing east (Figure 17).
Heads	
Shell	B-L dent/buckle 5'(long.) x 8' (trans.), about 2' deep, with jacket gouge and scrape mark leading into the dent
Bottom outlet valve	The BOV nozzle and operating handle were not damaged.
Top fittings, PRD and Manway	
Stub sills and couplers	The A-end coupler shank was fractured at the striker plate.
Other	No commodity loss.

14(a) A-L side and B-end head.

14(b) B-L dent/buckle, 5' x 8', adjacent gouge and scrape marks.

14(c) B-end head and right side.

14(d) BOV operating handle and undamaged nozzle extension.

Table A-15: Tank Car FURX 160024

Consist order	33 (66)
Specification/builder	DOT-117J100W, Gunderson
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest perpendicular to the direction of travel and upright with the B-end facing west (Figure 17).
Heads	
Shell	The B-R jacket was dented 5'x5'.
Bottom outlet valve	The BOV nozzle was undamaged; the operating handle was missing. The ball valve extension shaft securement pin was in place.
Top fittings, PRD and Manway	Multihousing lid was bent (wrecking damage?).
Stub sills and couplers	
Other	The B-R body bolster was bent toward the B-end and its top plate was cut. No commodity loss.

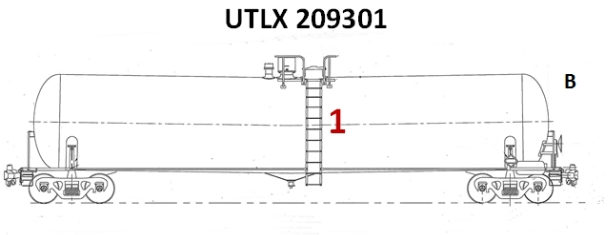
15(a) A-end head.

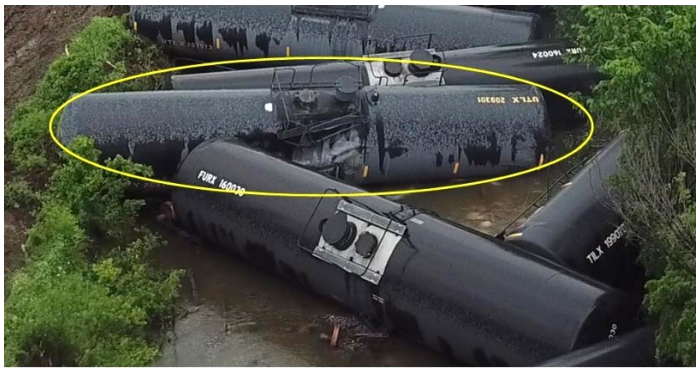
15(b) Right side.

15(c) B-end head and B-R jacket dent, 5' x 5'.

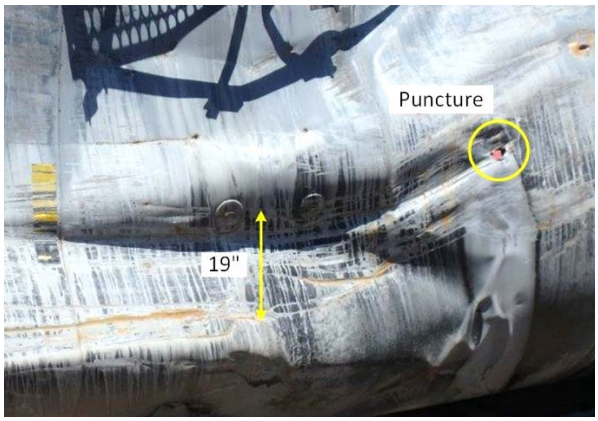
15(d) Missing BOV operating handle and undamaged nozzle extension. The ball valve extension shaft securement pin was in place.

Table A-16: Tank Car UTLX 209301

Consist order	34 (65)
Specification/builder	DOT-117R100W, Union Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest perpendicular to the direction of travel and upright with the A-end facing east. The B-end head of (36/63) FURX 160030 came to rest at a 45° angle against the A-L side of the car (Figure 17).
Heads	The B-end head shield received a rounded dented about 9 o'clock, measuring 2'x3' and about 8" deep. A second shallow B-end head shield dent was located about 10 o'clock, about 2' x 2', with a 1" wide gouge across its center.
Shell	**Breaching damage:** The shell sustained a 2" diameter circular puncture through its jacket and tank wall at the B-L midsection of Ring 2. A 19" wide impact mark/gouge within an 8' (circ.) x 13' (long.) x 13" (deep) dent extended across jacket from the puncture toward the A-L side of the shell where the B-end head of FURX 160030 came to rest. Jacket was torn across the bottom of the dent, with a 2'long 1" wide gouge mark on the tank shell. Other damage: The A-R side received a jacket dent about 4'(long.) x 6' (trans.). Jacket was buckled at the top of the dent.
Bottom outlet valve	The BOV nozzle was missing, the operating handle was not damaged.
Top fittings, PRD and Manway	The left side of the multihousing pad-to-tank weld was fractured where underlying buckled tank shell from the B-L to A-L dent extended to the top of the tank.
Stub sills and couplers	
Other	 *Breaching damage location.* About 9,112 gallons of ethanol released from this tank car.



16(a) UTLX 209301 as found in the derailment scene, showing position of impacting car FURX 160030.



16(b) Puncture location and 19" wide gouge marks.

16(c) Left side overall impact damage.

16(d) Tank jacket peeled away from the puncture location.

16(e) A-end head and A-R 4'x6' dent.

16(f) B-end head dents, 2' x 3' and 2'x 2'.

Table A-17: Tank Car TILX 199078

Consist order	35 (64)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest leaning to its right side, at about a 45° angle to the track with the A-end facing southwest off the right of way and the B-end remaining on the right-of-way (Figure 17).
Heads	The B-end head shield sustained a shallow rounded dent at center, about 1'x1.5'. Jacket was buckled behind the A-end head.
Shell	Deep dent to the A-L side, about 5' (trans.) x 8'(long.), sharp buckle in center.
Bottom outlet valve	The BOV nozzle was sheared from the flange and hanging by its chain. The Operating handle was bent, but its sleeve was in place with the BOV adapter shaft off-center and separated from the valve stem slot. The ball valve was closed. The skid protection structure was bent down the center.
Top fittings, PRD and Manway	
Stub sills and couplers	The B-end stub sill was fractured and separated at the head brace. The A-end coupler and shank was missing.
Other	The A-L bolster was crushed to the tank, with the top plate fractured above the lifting lug. No commodity loss.

17(a) B-*end head and right side.*

17(b) A-L dent, 5' x 8', depth was not measured.

17(c) The B-end stub sill was fractured at the head brace.

17(d) The BOV operating handle was bent, with extension sleeve disengaged from the valve stem.

Table A-18: Tank Car FURX 160030

Consist order	36 (63)
Specification/builder	DOT-117J100W, Gunderson
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest leaning on its right side and diagonally across the right-of-way, with the B-end head facing southeast and in contact with the left side of UTLX 209301 (Figure 17).
Heads	The B-end head shield had several arcing gouges from mid to top. The brake wheel was crushed, and its center nut and shaft were bent toward the left. The A-end head sustained a rounded 4'x4' dent in center, about 12" deep.
Shell	The lower A-L side was dented 5'(trans.) x 6' (long.)
Bottom outlet valve	The operating handle was missing, and its sleeve was bent upward. The BOV securement pin was in place. The BOV nozzle was missing.
Top fittings, PRD and Manway	
Stub sills and couplers	The B-end coupler top shelf was fractured, and left side of the striker plate was marked and rounded. The A-end draft sill was bent downward a couple of inches.
Other	No commodity loss.

18(a) B*-end head, crushed brake wheel and head shield gouges.*

18(b) A-end head dent, 4' x 4', 12' deep.

18(c) Lower A-L dent 5' x 6'.

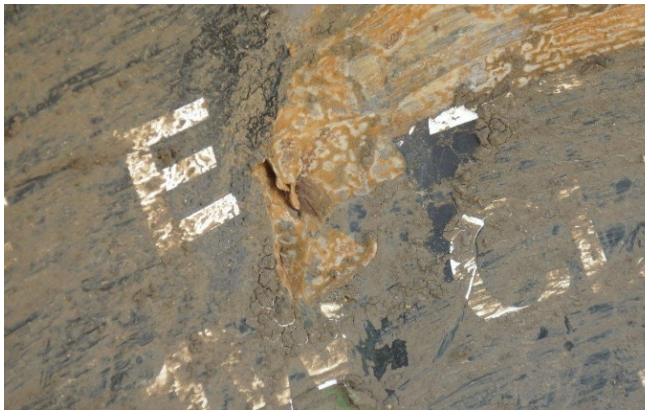
18(d) BOV operating handle and nozzle were missing, securement pin was in place.

Table A-19: Tank Car TILX 192495

Consist order	37 (62)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	A-end leading
Derailed resting position	The car came to rest upright and diagonally across the right-of-way, with the A-end head facing southwest.
Heads	The A-end head sustained a 3’ x 4’ rounded dent below center, in the center of which was a 1” long non-penetrating deep gouge in the head shield. Jacket behind the head was wrinkled.
Shell	
Bottom outlet valve	The BOV operating handle was bent inward, the extension shaft was not engaged with the ball valve extension. The BOV nozzle was not damaged.
Top fittings, PRD and Manway	
Stub sills and couplers	The B-end coupler was still engaged with the separated B-end coupler from adjacent car (38/61) TILX 194312.
Other	The A-L bolster was bent 45° toward the B-end. No commodity loss.

19(a) B*-end head and left side of the tank car.*

19(b) A-end head dent, 3’ x 4’ below center.



19(c) Gouge in the center of the dent noted in Figure 19(b).

19(d) BOV operating handle was bent, the nozzle was not damaged

Table A-20: Tank Car TILX 194312

Consist order	38 (61)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest upright and diagonally across the right-of-way, with the B-end head facing southeast.
Heads	A-end head shield sustained a 2’ x 3’ rounded dent at 8 o’clock.
Shell	
Bottom outlet valve	The BOV nozzle and operating handle were not damaged.
Top fittings, PRD and Manway	
Stub sills and couplers	The B-end couple and shank was missing and was found attached to the B-end coupler of the adjacent car (37/62) TILX 192495. The B-end stub sill was fractured from the car at the head brace.
Other	No commodity loss.

20(a) Left side showing no derailment damage.

20(b) A-end head 2’x3’ head shield dent at 8 o’clock.

20(c) Fractured B-end stub sill and missing coupler.

20(d) BOV operating handle and nozzle were not damaged.

Table A-21: Tank Car TILX 363442

Consist order	39 (60)
Specification/builder	DOT-117J100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest upright and diagonally across the right-of-way, with the B-end head facing southwest.
Heads	The A-end head had a 1'x1' jacket dent about 2 o'clock.
Shell	
Bottom outlet valve	The BOV nozzle and operating handle were not damaged.
Top fittings, PRD and Manway	Car was equipped with a Transquip USA, Inc., non-pressure car 6-bolt manway cover assembly, approved for service trial ST-470, AAR approval no. E172126, (9/27/2017). This equipment was not challenged in the derailment.
Stub sills and couplers	
Other	No commodity loss.

21(a) A-end head shield dent about 2 o'clock..

21(b) B-end head and left side.

21(c) Undamaged BOV operating handle and nozzle.

21(d) Transquip 6-bolt manway assembly under AAR service trial no. ST-470.

Table A-22: Tank Car UTLX 209496

Consist order	40
Specification/builder	DOT-117R100W, Union Tank Car
Orientation in the consist	B-end leading
Derailed resting position	The car came to rest upright and diagonally across the right-of-way, with the B-end head facing southeast.
Heads	
Shell	The A-R jacket was dented 2'(long.) x 6' (trans.). B-L jacket dent (not measured).
Bottom outlet valve	The BOV nozzle and operating handle were not damaged.
Top fittings, PRD and Manway	
Stub sills and couplers	
Other	No commodity loss.

22(a) B-end head.

22(b) Left side jacket dent.

22(c) A-end head.

22(d) Undamaged BOV operating handle.

Table A-23: Tank Car TILX 191499

Consist order	41 (58)
Specification/builder	DOT-117R100W, Trinity Tank Car
Orientation in the consist	B-end leading
Derailed resting position	This was the last derailed tank car, which came to rest upright with its leading B-end trucks derailed and to the west of the track.
Heads	
Shell	
Bottom outlet valve	
Top fittings, PRD and Manway	
Stub sills and couplers	
Other	No derailment damage noted other than superficial scratches. No commodity loss.

23(a) B-end head and left side.

23(b) B-end head.

23(c) Disengaged BOV operating handle extension.

List of Attachments