HAZARDOUS MATERIALS GROUP
FACTUAL REPORT ADDENDUM

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

Fort Worth, Texas

RRD19FR007

Report Date: November 14, 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

B. Hazardous Materials Group

Paul L. Stancil, CHMM
Sr. Hazardous Materials Accident Investigator
Hazardous Materials Group Chairman
National Transportation Safety Board
Washington, D.C. 20590

Edward Komarnicki
Engineering Technician
National Transportation Safety Board,
Washington, D.C. 20590

Adam (A.J.) Konrad
Package Engineer
Federal Railroad Administration
Washington, D.C. 20590

Francisco Gonzalez, III
Hazardous Materials and Tank Car Project Manager
Federal Railroad Administration
Washington, D.C. 20590

Leonard Majors
General Engineer
Engineering and Research Division
Pipeline and Hazardous Materials Safety Administration
Washington, D.C 20590

Ron Lawler
Sr. Director Mechanical Services
Trinity Industries Leasing Co.
Dallas, TX 76106

Joseph Perez
Vice President, Fleet Engineering
Union Tank Car Company
Chicago, IL 60604

Timothy O'Brien
Director Hazardous Materials Management-Safety
Union Pacific Railroad
Spring, TX 77373

Keiran (Kurt) Stewart
Accident Investigator
Pipeline and Hazardous Materials Safety Administration
Oklahoma City, OK 73179

Gregory Saxton, P.E.
Senior VP & Chief Engineer
Manufacturing Operations
The Greenbrier Companies
Portland, OR 97210

Vernon Walker
Tank Car Specialist
Federal Railroad Administration
Washington, D.C. 20590

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 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.

D. Examination Details Breached Tank Car Parts

On October 22, 2019, selected members of the Hazardous Materials Group participated in an examination of parts recovered from breached tank cars involved in the Fort Worth, Texas derailment. The examination took place at the NTSB Training Center, 45065 Bles Park Drive, Ashburn, Virginia. The components examined included:

- UTLX 209301, approximately 18-inch square tank shell coupon with score, dent, and puncture features taken from left side of the car in Ring 2 (Figure 1).
- FURX 160030, approximately 28-inch square head-shield coupon with impact-damaged hand brake (Figures 2 and 3).
- UTLX 209403, approximately 24 x 36-inch breached shell plate with B-L body bolster pad (Figures 4 and 5).

[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.

The tank cars were involved in a derailment with an initial speed of 26 mph and were carrying denatured ethanol as part of a high-hazard flammable unit train. UTLX 209301 was the 18th derailed car and was in position 34 of the consist with the A-end leading. UTLX 209403 was the 7th derailed car and was in position 23 with the B-end leading.

UTLX 209301 and UTLX 209403 were specification DOT-117R tank cars that had been converted from specification DOT-111A100W. The original tank shell thickness was 0.4375 inch, AAR TC128 Gr. B steel. Union Tank Car Company built both tank cars in 2007. The conversion work included a ½-inch-thick ceramic fiber thermal protection blanket, ½-inch-thick head shield, and an 11-gauge jacket. Before shipping to NTSB, any remaining jacket and thermal protection material was removed from the tank parts to be examined.

FURX 160030 was in position 36 of the consist and came to rest with its B-end head in contact with the shell of UTLX 209301 near its breached location. FURX 160030 was a specification DOT-117J100W. The heads and shell were constructed from 0.563-inch AAR TC-128 Gr. B normalized steel. The tank heads were equipped with full ½-inch-thick head shields. The Greenbrier Companies built the tank car in 2016.

UTLX 209403 Observations

Internal shell:

- The entire internal surface exhibited general corrosion and roughening in which there appeared to be uniform metal loss with interconnecting cavities.[2]
- The shell fracture origin, as determined by fracture face indications, was a 2-inch wide brittle/fast fracture region parallel to a fractured B-side bolster pad fillet weld (Figure 6, location A).
- The shell fracture followed the edge of the fractured bolster pad fillet weld 14-inches in a circumferential direction along the A-side of the bolster pad (Figure 6, location B).
- The width of shell breach was 5 ½-inches longitudinally (Figure 6, location C).
- Folded shell material at A-end side of breach 14-inches longitudinally formed a 3 1/8-inch-deep crease (Figure 6, location D).
- Fractured bolster pad produced a 4 ½-inch opening above the breached shell (Figure 6, location E).
- A separate 4-inch fracture was located midway between bolster pad fillet welds, within region of inward deformation (Figure 6, location F). Visible cracks in the corrosion layer within this bulged area produced a crumbling appearance.
- The origin of the shell fracture and the tank breach are shown in Figure 7.

[2] The terms general corrosion and roughening are defined in Union Tank Car's tank head and shell corrosion inspection standard RES-028, Rev.K. General corrosion is uniform metal loss where the entire surface displays a similar appearance. Roughening refers to a cavity, such that the diameter at the metal surface exceeds the thickness of the plate.

External shell:

- The bolster pad surface was marked with three scores or wheel burns, having characteristic features of circular cuttings, striations, and metal flow (Figures 8-11).
- Wheel burn #1 at the lowest point on the bolster pad was 1-inch wide.
- Wheel burn #2, located above #1 and below the breached area was about 1 1/8 to 1 ½-inch wide. The wheel burn mark extended across the bolster pad and onto the tank shell, but these marks were offset by the bolster pad buckling.
- Wheel burn #3 was situated on the B-side of the bolster pad at the point of origin of the tank shell fracture and near the edge of the bolster pad fracture referenced in Figure 6 location E.
- Immediately adjacent to the tank shell breach was an 18-inch area that was buckled inward between wheel burns #1 and #3 (Figure 12). The earlier staging area tank car examination showed that this deformation extended beyond the bolster region into the B-end head.[3]
- The B-side bolster pad fillet weld was fractured throughout the length of the inwardly deformed shell segment. The tank shell fracture also followed the heat affected zone of this fractured fillet weld.
- The fracture origin surface was measured with calipers, finding 0.3585-inch of thickness. Of this, about 0.1760-inches appeared to be shiny metal. Additional examination of the tank shell material in the region of the fracture origin is scheduled.

UTLX 209403 Ultrasonic Thickness Testing (UT)

Material thickness measurements on the UTLX 209403 tank coupon were in the a region considered to be top shell, as described in Union Tank Car Company tank head and shell corrosion inspection procedure and fleet repair standard for Qualification of Tank Cars.[4] Union Tank Car determined that the minimum allowable thickness for uniform corrosion in the top shell region was 0.313-inch.[5]

Four ultrasonic thickness (UT) test locations were selected, two on each side of the shell breach and in locations exhibiting minimal buckling (Figure 13). A Union Tank Car Company level III NDT technician collected UT measurements from the interior surface.[6] Corrosion was removed by grinding to shiny metal prior to measuring shell thickness.

[3] See Table A-5 in the Hazardous Materials Group factual report for a description of the B-end head damage for tank car UTLX 209403.

[4] According to 49 CFR 171.8, bottom shell means that portion of a tank car tank surface, excluding the head ends of the tank car tank, that lies within two feet, measured circumferentially, of the bottom longitudinal center line of the tank car tank. Top shell means the tank car tank surface, excluding the head ends and bottom shell of the tank car tank.

[5] Union Tank Car determined the minimum allowable head and shell thicknesses in accordance with 49 CFR 180.509(g). See Section I of the Hazardous Materials Group Factual Report.

[6] The equipment used was Union Tank Car's Danatronics Echo 8 FD ultrasonic flaw detector and thickness gauge.

Table 1. Shell thickness measurements adjacent to tank breach.

Location	Thickness (inch)	Location	Thickness (inch)
C	0.404	D	0.403
A	0.421	B	0.419
Bottom of Plate			

UTLX 209301 and FURX 160030 Observations

- The center hole of the FURX 160030 hand brake wheel hub was deformed such that the wheel detached from the rest of the hand brake assembly (Figure 3).
- The brake wheel trunnion was bent about 45-degrees toward the left (Figure 14 left).
- The nut and trunnion was removed from the brake wheel assembly and inserted into the punctured shell plate of UTLX 20930, where it was manipulated until it dropped into place (Figure 14 right)
- The end of the trunnion measured 0.761-inch, and across the threads was 0.892-inch (Figure 15). The trunnion was fractured inside of the handbrake body, about 6-inches from its end.
- The nut measured 1.414, 1.416, and 1.427-inch across the hex flats.
- Flat measurement for a new analog nut was 1.418-inch. Hex point-to-point measured 1.621 inch.
- The breach in the UTLX 209301 tank shell coupon measured 2.290 x 2.021 inches.
- A rounded mark found on an inwardly deformed flap of steel at the puncture site measured 0.720-inch (Figure 16).

E. <u>Previous Incidents of Hand Brake Component Tank Shell Puncture Damage</u>

NTSB investigators found there is little data available for evaluating the frequency of previous incidents in which hand brake components were implicated in tank car shell punctures.

In response to an October 28, 2019, request for RSI-AAR Railroad Tank Car Safety Research and Test Project accident database information about the number of previous incidents for brake wheel component involvement in tank car punctures, the project director told NTSB investigators that the RSI data does not differentiate between tank breach causes for most tank cars in its database.

A search of the PHMSA hazardous materials incident database, composed of data collected from incident report Forms 5800.1, found only one documented incident in which the report narrative specifically describes a hand brake wheel stem puncturing the shell of a tank car. According to incident report I-1999020853, on January 21, 1999, a Conrail train derailed 32 cars in Nelliston, New York, including 20 cars containing hazardous materials. The incident report stated the handbrake operating stem of tank car CITX 33376 impacted and punctured the tank shell of UTLX 37485, a Class DOT-112 tank car, creating a small pinhole that allowed UN1075 Liquefied Petroleum Gas (LPG) to escape. Contractors successfully transloaded and flared the remaining LPG from the punctured tank car.

F. Material Test Reports UTLX 209301

The NTSB contracted Lehigh Testing Laboratories to conduct a series of mechanical and chemical tests for the shell plate coupon extracted from UTLX 209301, barrel section #2. All parameters were within specification except for ultimate tensile strength (UTS) tests of three longitudinal and three transverse specimens that did not meet the requirements of AAR TC-128 Gr. B steel.[7] According to the AAR Manual of Standards and Recommended Practices, M-1002, M5.5, the acceptable tensile strength for AAR TC-128 Gr. B steel is 81,000 – 101,000 psi.

Union Tank Car Company provided Mittal Steel USA, Burns Harbor Plate mill test reports for each of the UTLX 209301 barrel sections when the steel was produced in June 2007. The mill test results for each barrel section are listed in Table 2, while yield strength and elongation results are shown in Table 3. These tables show as-rolled material test results compared with those from post-accident testing of the tank shell coupon.

Table 2. Manufacturer's reported tensile strengths for steel used to construct UTLX 209301 compared with NTSB post-accident testing.

Shell Barrel Number	Mittal (2007) Tensile Strength (psi)	NTSB (2019) Long. UTS (psi)	NTSB (2019) Trans. UTS (psi)
#1	91,500		
	92,500		
	91,000		

[7] See Materials Laboratory Factual Report 19-054 contained in the docket for this investigation. The barrel section #2 shell coupon was taken from the opposite (right) side of the tank from the breach. This area of the shell did not exhibit any visible thermal or impact damage. Mechanical properties were determined using ASTM A370-18.

#2	89,100	77,400*	76,500*
	89,500	77,500*	76,700*
	89,700	77,700*	76,200*
#3	81,500		
	82,600		
	81,200		
	82,400		
#4	81,500		
	82,600		
	81,200		
	82,400		

* Does not meet requirements for AAR TC-128 Gr. B steel.

Table 3. Comparison of manufacturer's as-rolled to NTSB post-accident yield strength and percent elongation tests for material used to fabricate UTLX 209301 barrel section 2.

	Mittal (2007) Yield Point (psi)	NTSB (2019) Yield Strength (psi) 2% offset longitudinal	NTSB (2019) Yield Strength (psi) 2% offset transverse	Mittal (2007) Elongation % in 8"	NTSB (2019) Elongation % in 8" longitudinal	NTSB (2019) Elongation % in 8" transverse
	66,200	50,300	54,700	18	22	23
	67,200	51,600	54,600	17	23	24
	68,200	51,000	54,400	17	25	23
AAR (M5.5)	50,000 (min.)			16.0 (min.)		

Given the noted data discrepancies in Tables 2 and 3 with the 2007 steel manufacturer's mill test report, the NTSB anticipates additional mechanical testing to validate the above referenced post-accident tests.

ADDENDUM ATTACHMENT 1 – MITTAL STEEL USA MILL TEST REPORTS FOR MATERIAL USED TO FABRICATE UTLX 209301, JUNE 2007.

G. Top Fittings Protection Retrofit

As the top fittings protective housing on UTLX 209403 was severed from the flange, the vapor valve, liquid valve, vacuum relief device, and a blind flange were all torn from the top fittings flange, exposing four openings into the tank from which product leaked and ignited.

Top fittings protective housings for specification DOT-117R tank cars must conform to the requirements of 49 CFR 179.202-13(h) and AAR MSRP M-1002 Appendix E, paragraph 9.3.1, which among other things, requires the design to be no less than either 40 percent, but not greater than 70 percent, of the nozzle to tank tensile connection strength. Alternatively, the regulation and the AAR standard provide prescriptive requirements that the housing be attached with twenty ½-inch bolts of unspecified strength.

Post accident inspection found that the protective housing had been attached to the flange with only ten ½-inch bolts. According to Union Tank Car's design criteria, the ratio of the strength of the protective housing to the nozzle-to-tank attachment was 62%. The approved AAR Certification of Construction for this modification (M157044A) also referenced a drawing that shows the ten-bolt attachment configuration.[8]

In August 2015, Union Tank Car conducted an evaluation of top fittings protection options for Class DOT/TC 117R tank cars to demonstrate compliance of its design with the AAR standard.[9] Finite element analysis suggested that using standard high strength fasteners to secure the protective housing was inappropriate because damage to the housing would likely result in nozzle failure. Union Tank Car determined that a lower-strength material grade fastener composed of ten ½-inch SAE J429 Grade 1 bolts, would fail at 62% of the loading that would cause nozzle failure.

H. <u>Tank Car Train Placement Practices</u>

There are no federal regulations, industry standards, or best practices governing the make-up of trains by tank car specification; that is, the distribution of tank cars within a train based on their positional likelihood of derailing in an accident in combination with their probability of releasing hazardous materials based on individual construction criteria.

Some ethanol refineries use loop track facilities to improve loading efficiency. To maintain unit trains intact for loading in a single pass, a shipper must have continuous loop track long enough to accommodate the entire train.[10] The Cargill logistics manager told NTSB investigators that because of space limitations, its Blair, Nebraska ethanol refinery facility does not have loop track to facilitate unit train loading.[11] Instead, Cargill loads ethanol in blocks of 20 tank cars and the trains are assembled by the rail carrier off-site. Thus, the rail carrier arranges the train as received and in no particular order. The logistics manager also

---

[8] See Hazardous Materials Group Factual Report Attachment 12.

[9] K. Peltason, memorandum, "Investigation of Non-Pressure Tank Car Fittings Nozzle and Analysis of Top Fittings Protection for Class DOT/TC-117R Tank Cars," Union Tank Car Company, August 13, 2015.

[10] K. Loria, "Loop Track Comeback." *Ethanol Producer Magazine*. October 16, (2017) pp.36-39.

[11] S. Britton, Cargill, telephone conversation with P. Stancil, October 9, 2019, National Transportation Safety Board, Washington, DC.

stated that while Cargill has not been marshalling tank car consists to manage risks associated with legacy DOT-111 tank cars, it's fleet of leased tank cars currently consists of about 5 percent DOT-111s and the company is committed to removing them from service before the regulatory deadline.

According to the Renewable Fuels Association (RFA), the ethanol industry's 2018-2019 YTD unit train share of ethanol gallons shipped by rail is approximately 60% based on sampled railroad data.[12] Some ethanol biorefineries offer both unit trains and manifest train shipments. When shipped by unit train, these trains are typically assembled at the shipper's facility.

Questioned about logistical challenges to organizing train consists to take advantage of placing more robust cars, such as Class 117J, in the more derailment-prone and high-energy locations of a train, the RFA vice president of regulatory affairs told NTSB investigators:

> Would need more personnel and time which would increase costs and reduce efficiencies. Would need track space and switches like a loop track to arrange the cars in a specific order. There are a few loop track locations. Consider that moving cars in the yard is a hazard for personnel, increasing these moves will put workers at increased risk of accident. Also, managing the fleet would be difficult to ensure you had enough 117J cars every time you wanted to go to one of these areas. Could miss some trades/deadlines.

Paul L. Stancil
Sr. Hazmat Accident Investigator

[12] K. Davis, Renewable Fuels Association, e-mail ("NTSB Information Request, Fort Worth TX Investigation (RRD19FR007") to P. Stancil, National Transportation Safety Board, November 7, 2019. Only waybills with 75 or more railcars were used for determining whether ethanol shippers offered shipments via unit train.

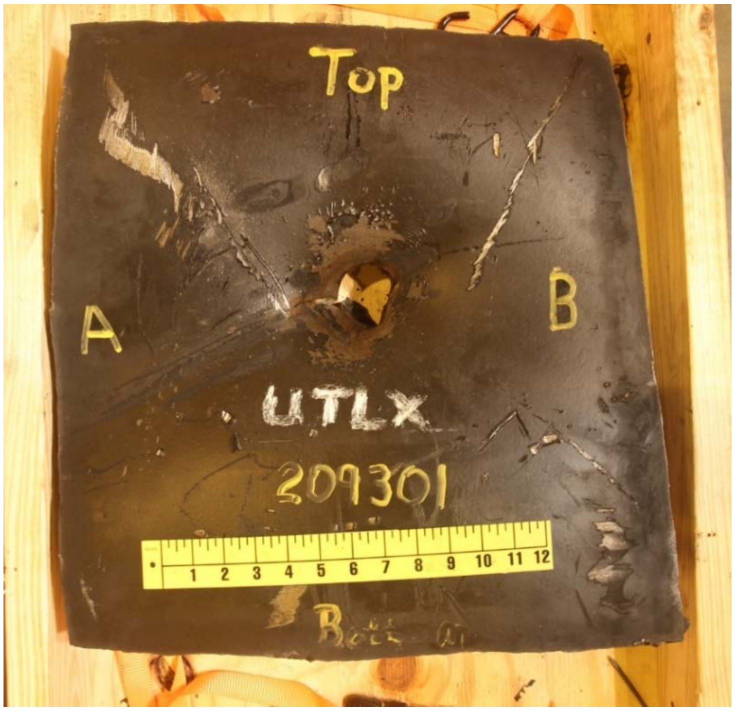

Figure 1. UTLX 209301 shell coupon with puncture, left side Ring 2.

Figure 2. FURX 160030 head shield coupon with hand brake assembly (missing hand wheel).

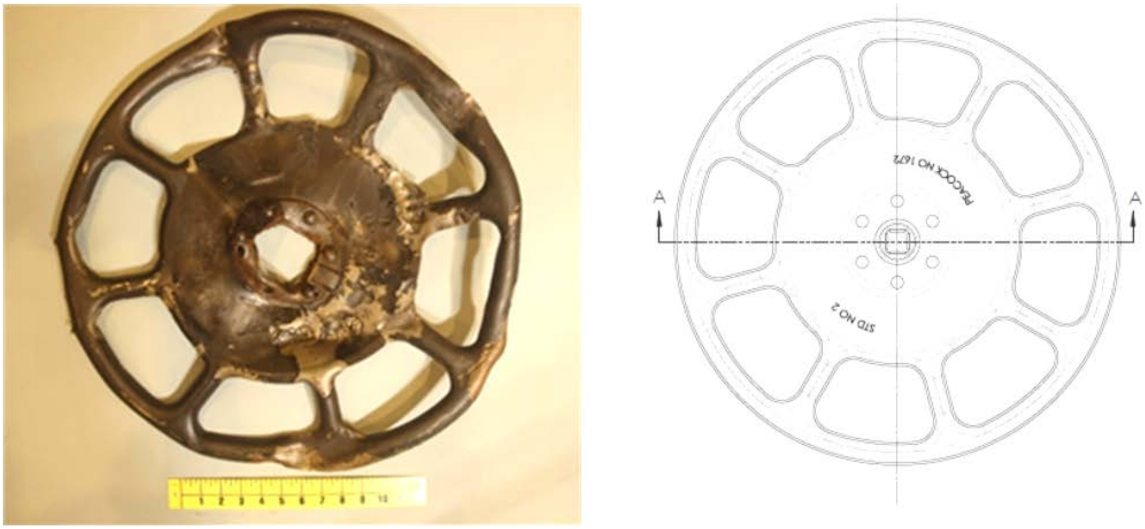

Figure 3. FURX 160030 brake wheel separated from hand brake nut and trunnion, and excerpt from Amsted Rail 22-inch diameter hand wheel drawing.

Figure 4. UTLX 209403 breached B-L shell plate interior surface.

Figure 5. UTLX 209403 breached shell plate with B-L body bolster pad, exterior surface.

Figure 6. UTLX 209403 tank coupon interior surface with noted measurements and fracture/tear features.

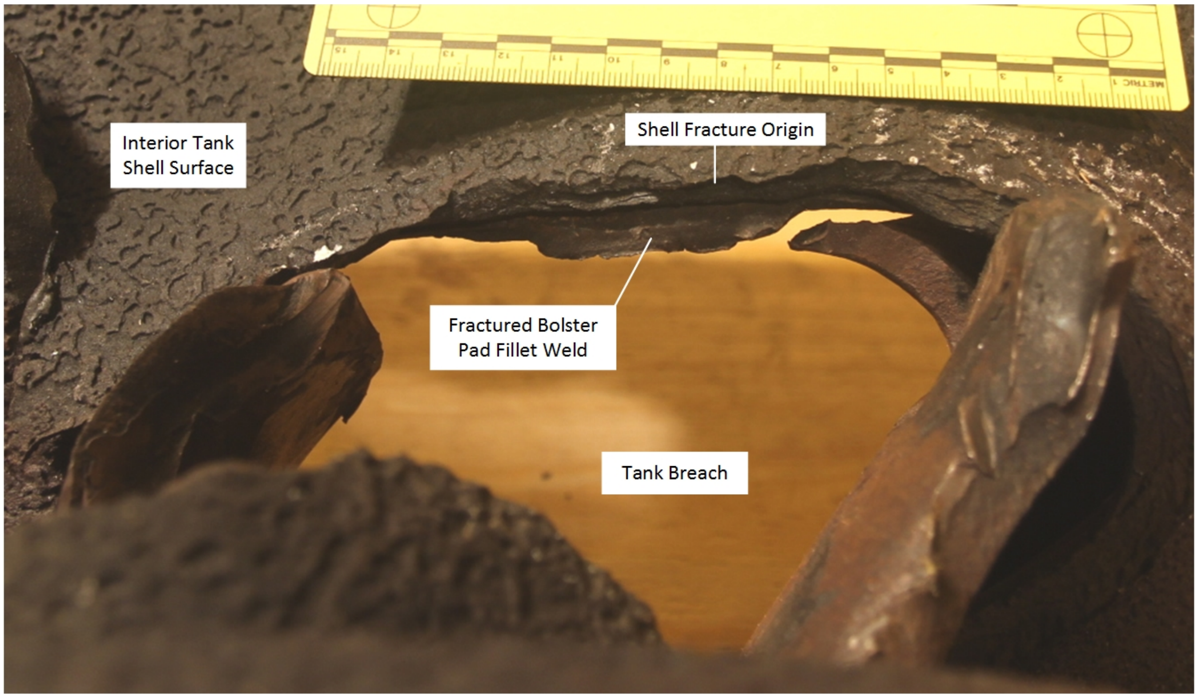

Figure 7. UTLX 209403 shell plate coupon showing the tank breach created by fractured shell material. The origin of the shell fracture is indicated adjacent to fractured bolster pad fillet weld material.

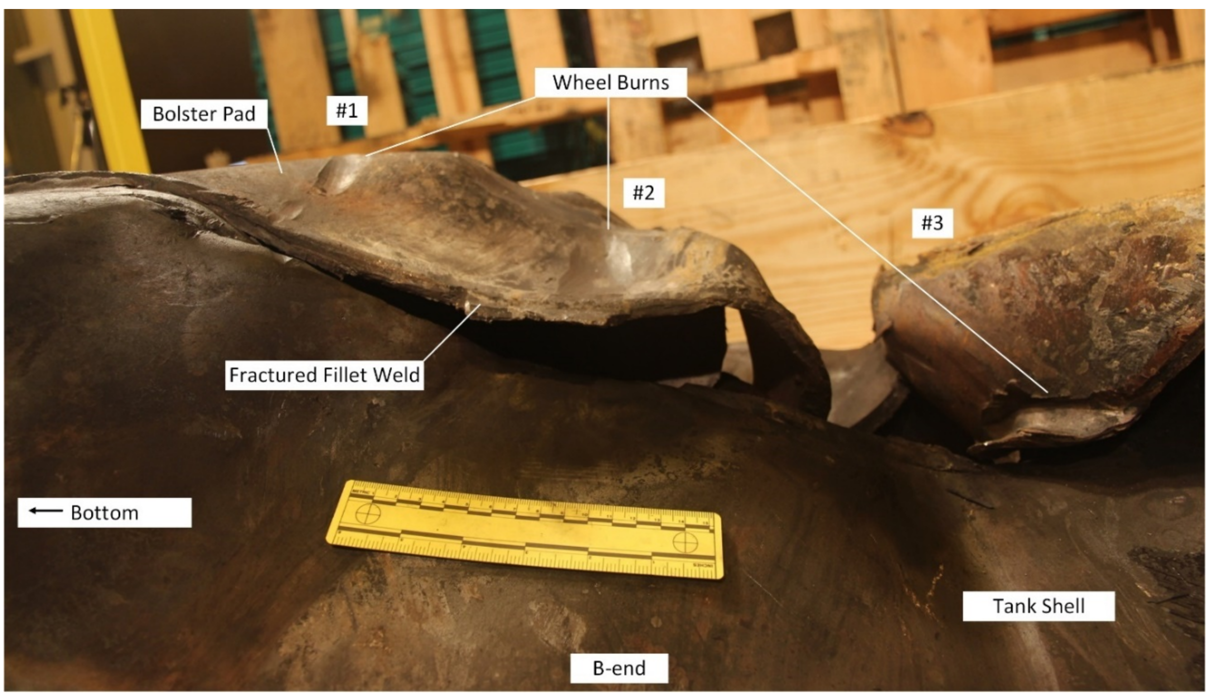

Figure 8. UTLX 209403 shell plate coupon side view showing three gouges, or wheel burns in the bolster pad. Wheel burn #3 was situated next to the origin of the shell fracture.

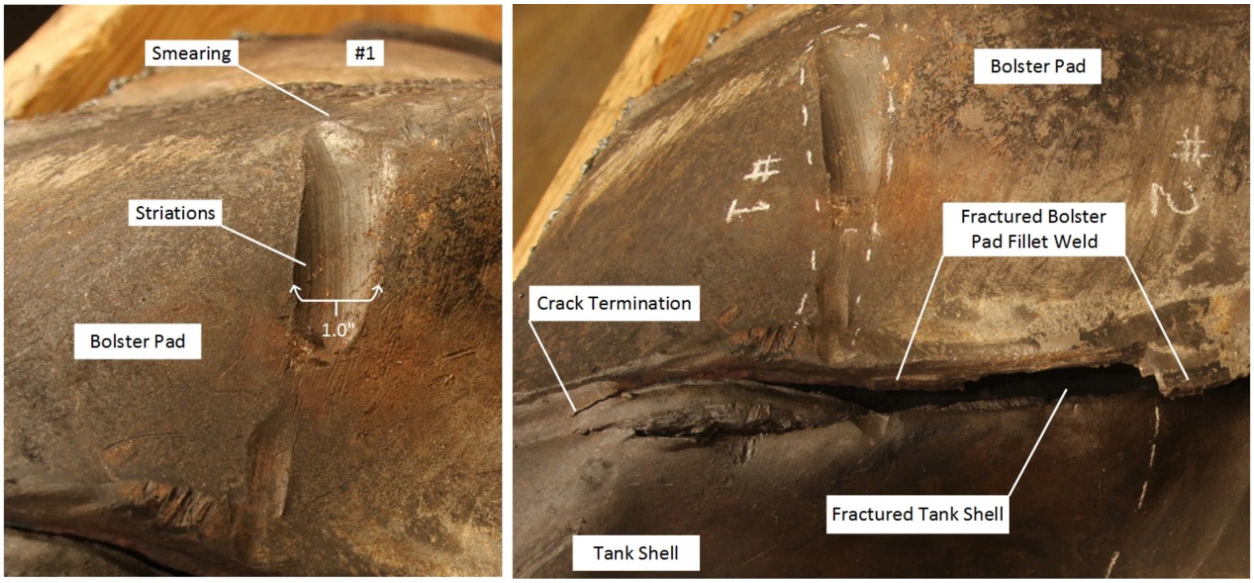

Figure 9. UTLX 209403 close view of gouge or wheel burn #1 across the lower portion of the bolster pad showing striations and metal flow (smearing) toward the A-end (left). The lower B-side termination of the shell crack is shown in the right photograph.

Figure 10. UTLX 209403 tank shell coupon from B-L bolster region showing outlined extent of wheel burn marks at locations #1 and #2.

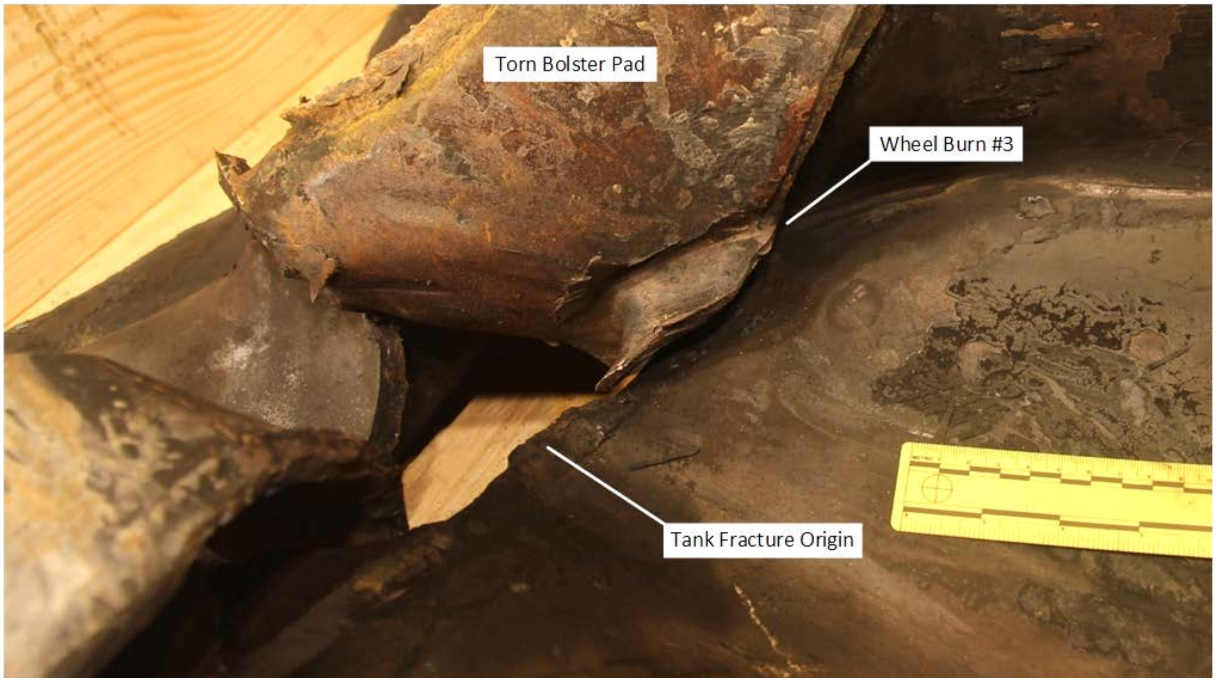

Figure 11. UTLX 209403 proximity of wheel burn #3 to tank fracture origin.

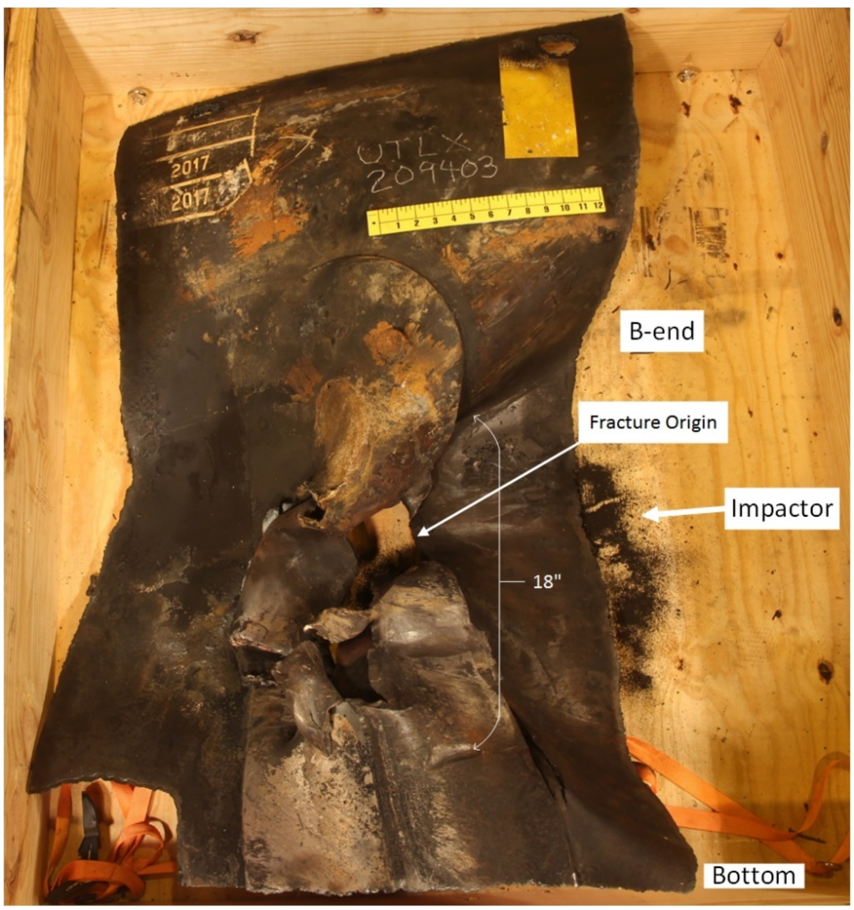

Figure 12. UTLX 209403 tank shell coupon from the B-L bolster region showing the shell fracture origin and buckled shell dimensions.

Figure 13. UTLX 209403 tank shell coupon B-L bolster region, ultrasonic thickness measurement locations A through D. Shiny circular areas are locations where corrosion was ground away before testing.

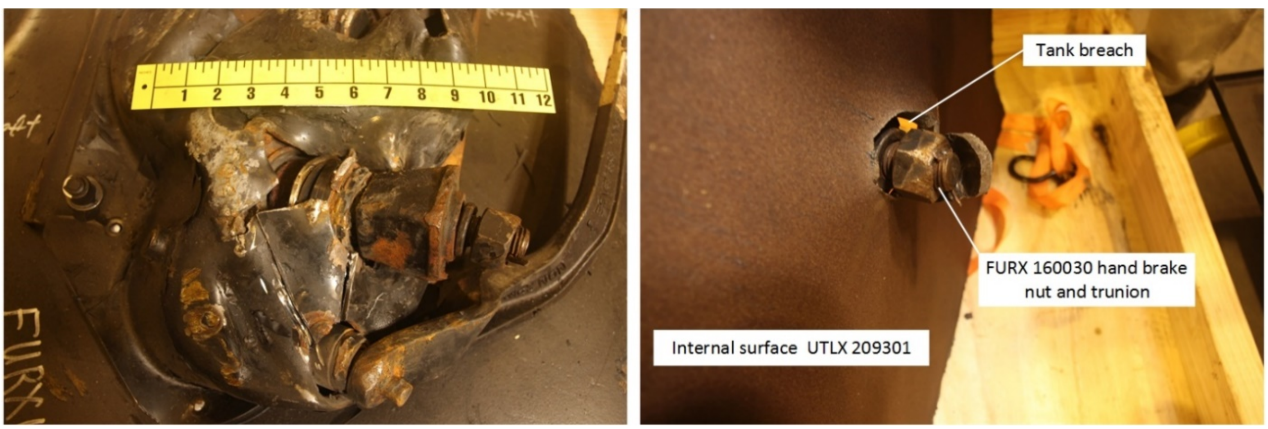

Figure 14. FURX 160030 brake wheel assembly (left). UTLX 209301 punctured tank shell coupon with nut and trunnion inserted for fit test (right).

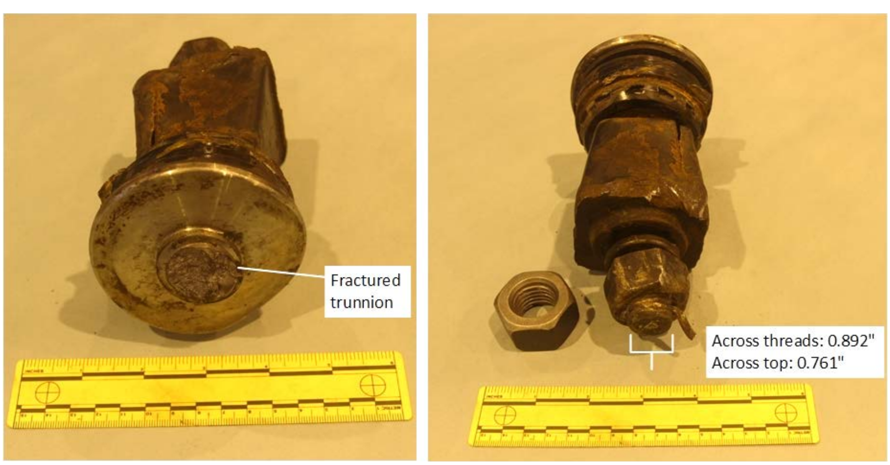

Figure 15. FURX 160030 fractured brake wheel trunnion rear view (left). Front view (right) with trunnion measurement notations, and exemplar brake wheel nut.

.

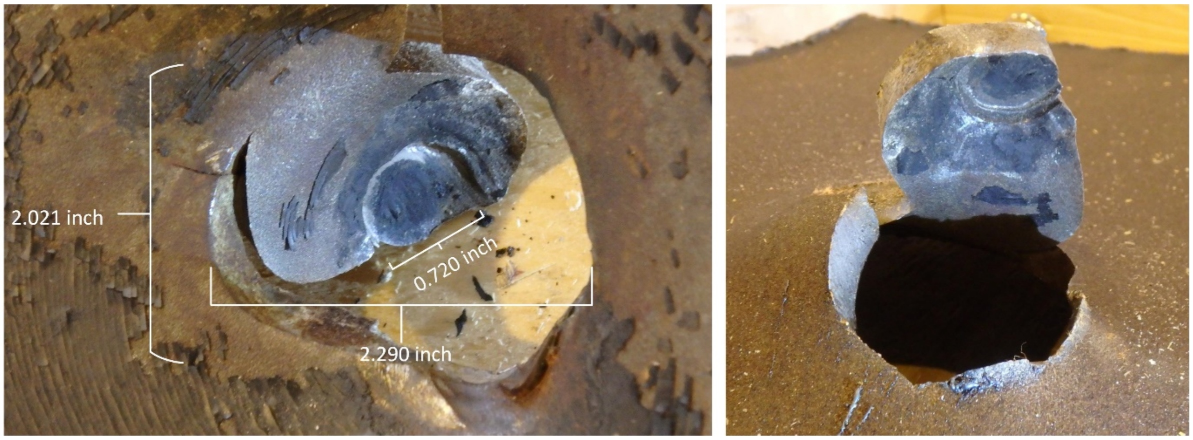

Figure 16. UTLX 209301 shell coupon left side Ring 2 external surface with dimensions of puncture marks noted (left). The internal shell surface with flap of punctured steel is shown in the right photograph.

List of Attachments