HAZARDOUS MATERIALS GROUP
FACTUAL REPORT

Derailment of Union Pacific Railroad Train UEGKOT 09 with Subsequent Hazardous Materials Release Graettinger, Iowa, March 10, 2017

DCA17MR007

Report Date: August 9, 2017

Accident Identification

Carrier:	Union Pacific Railroad
Train No.:	UEGKOT 09
Location:	Graettinger, Iowa
Date/Time:	March 10, 2017 at 12:50 a.m.
NTSB No.:	DCA17MR007

A. Hazardous Materials Group Members

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B. Accident Summary

For a summary of the accident, refer to the *Accident Summary Report* contained in the docket for this investigation.

Figure 1: Accident scene at Jack Creek, Graettinger, Iowa

C. Hazardous Materials Shipper Information

The Green Plains, Inc. 2016 annual report states that it is the second largest consolidated owner of ethanol production facilities in the United States with 1.5 billion gallons of ethanol produced annually.[1] Green Plains, Inc. operates 17 ethanol plants in Indiana, Iowa, Michigan, Minnesota, Nebraska, Tennessee, Texas, and Virginia. The corporate subsidiary, Green Plains Superior LLC (Green Plains), facility located in Superior, Iowa has been in operation since July 2008, has a capacity of 63 million gallons per year, and employs 43 persons. The Superior, Iowa facility is situated on 238 acres, with 35,141 feet of paired rail track. The Green Plains operations/shipping supervisor and the

[1] *Green Plains Inc. 2016 Annual Report* accessed from http://greenplainsannualreport.com/ (accessed July 18, 2017).

laboratory manager told NTSB investigators that the company's Superior, Iowa facility on average produces 130,000 gallons per day to 165,000 gallons per day of ethanol depending on market conditions. On average, the plant originates two unit train shipments of ethanol per month, each containing between 80 and 112 tank cars. The Green Plains vice president of transportation and logistics told NTSB investigators that during 2016 the company shipped a total of 886 tank cars of denatured fuel ethanol and 976 tank cars of undenatured ethanol.[2] During the first quarter of 2017 the Green Plains facility originated only 17 tank cars of denatured fuel ethanol, while shipping 323 tank cars of undenatured ethanol. Since 2016, about 59% of the Green Plains ethanol shipments have been transported as undenatured product.

The Green Plains facility has a single loading rack and two storage tanks for intermediate storage of denatured or undenatured ethanol. The facility employs 4 loading personnel who receive annual hazardous materials employee and HAZWOPER training.

Figure 2: Green Plains Superior Ethanol Facility[3]

Attachment 1: Green Plains Superior, Iowa Railcar Count – Denatured vs. Undenatured Shipments

D. UP Train UEGKOT 09

Union Pacific Railroad train UEGKOT 09 was a unit train and key train with 3 locomotives (configured as 2 x 1, distributed power), two buffer cars and a total of 98 loaded tank cars containing ethanol which is designated by the U.S. Department of Transportation (DOT) as a Class 3 hazardous material.[4] The train was transporting 2,851,139 temperature-adjusted meter quantity gallons of undenatured ethanol. The accident train was also classified as a high hazard flammable train (HHFT)

[2] Federal requirements for denaturing fuel ethanol are discussed in Section G of this report.

[3] Company website: www.gpreinc.com

[4] The definition of "key train" is provided by Association of American Railroads publication OT-55-P, *Recommended Railroad Operating Practices for Transportation of Hazardous Materials,* January 19, 2016. "Key trains" are subject to speed restrictions and other operating criteria.

and subject to route planning requirements, speed restrictions, and DOT-117 compliance and reporting requirements of the Hazardous Materials Regulations (HMR).[5]

The conductor's train consist matched the physical placement of the derailed cars in the train with no exceptions. The consist order for the derailed cars was confirmed by automated equipment identification (AEI) consist information from site 509 Estherville East, March 10, 2017, 12:26 a.m.

The accident train was operating on the Estherville Subdivision, which does not meet the definition of a Key Route as defined in the Association of American Railroads Circular OT-55-P.[6] Association of American Railroads (AAR) requirements for Key routes include increased track and wayside bearing inspection frequencies. The AAR circular requires that main track on Key Routes be inspected by rail defect detection and track geometry inspection cars or any equivalent level of inspection no less than two times each year. Furthermore, wayside defective bearing detectors on Key Routes must be placed at a maximum of 40 miles apart, or an equivalent level of protection may be installed based on improvements in technology.

In accordance with final rule HM-251, carriers that operate HHFTs must perform a routing analysis that considers, at a minimum, 27 safety and security factors and select a route based on the findings.[7] The rule found at 49 CFR 172.820 requires rail carriers to select a practicable route posing the least overall safety and security risk to transport HHFTs and certain hazardous materials. The UP Railroad provided a Rail Corridor Risk Management System (RCRMS) hazardous materials route selection analysis for the route from Superior, Iowa to Texas City, Texas. The analysis did not provide an alternate route for the shipment of ethanol from the Superior, Iowa facility until the route entered the state of Missouri.

Attachment 2: Green Plains Superior Transfer Record and Inventory, Train UGGKOT 09
Attachment 3: Train Consist UEGKOT 09
Attachment 4: AEI Report UEGKOT 09 Estherville East, March 10, 2017
[redacted]

D. Hazardous Materials Description and Information

The bill of lading identifies the origin of the shipment as Green Plains Superior LLC ethanol refinery located at 1495 320th Avenue, Superior, Iowa 51363. The destination terminal was Murex LLC, C/O

[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. Specific operating requirements for HHFTs are found at 49 CFR 174.310.

[6] According to AAR Circular OT-55-P, a Key Route is any track with a combination of 10,000 car loads or intermodal portable tank loads of hazardous materials, or a combination of 4,000 car loadings of PIH or TIH (Hazard zone A, B, C, or D), anhydrous ammonia, flammable gas, Class 1.1 or 1.2 explosives, environmentally sensitive chemicals, Spent Nuclear Fuel (SNF), and High Level Radioactive Waste (HLRW) over a period of one year.

[7] See 80 *FR* 26644, May 8, 2015.

Oil Tanking Texas City LP, 2800 Loop I97 South, Texas City, Texas 77592. The bills of lading for each rail car describe the product as UN1170, Ethanol, PGII Hazardous Materials. The bills of lading provided the seal numbers and quantities loaded into each tank car.

Chemical and Physical Properties

The shipper provided a safety data sheet for the ethanol dated September 23, 2016, identifying the hazardous material as Ethanol, 200 Proof, a.k.a. Ethyl Alcohol, or Absolute Ethanol. The product was intended for use as gasoline additive/fuel ethanol, and not for use as an alcoholic beverage. According to the data sheet and confirmed by the Green Plains plant manager, the ethanol was not blended with denaturant and contains no impurities or stabilizing additives.

Attached to the bills of lading for the accident shipment were certificates of analysis and product specifications listing the following:

- Ethanol Vol% >99.3
- Acidity Mass % max 0.007
- Appearance clear and bright
- Chloride mass ppm max 40
- Copper content max 0.1
- Density max 0.7915
- Methanol Vol % max 0.5
- pH min 6.5 max 9
- Water Vol % max 0.45
- No denaturant content

The safety data sheet describes the material as a colorless liquid with a sweet odor, having a boiling point of 176 °F, and a flash point of 55 °F. The upper flammability limit is 19 Vol % and the lower explosive limit is 3.3 Vol %. The specific gravity is 0.790 (H_2O = 1).

According to the DOT Emergency Response Guidebook (ERG), guide number 127, ethanol is highly flammable and can easily be ignited. Ethanol vapors are heavier than air and can form an explosive mixture. The ERG recommends that if a tank, rail car or tank truck is involved in a fire, to isolate for 800 meters (1/2 mile) in all directions and to also consider an initial evacuation for 800 meters (1/2 mile) in all directions.

According to the Ethanol Emergency Response Coalition, undenatured ethanol fires do not produce visible smoke and have a hard-to-see blue flame. In denatured form, there is little smoke with a slight

orange visible flame.[8] While ethanol mixes easily with water and can be diluted to the point where it no longer supports combustion, it will burn even at five parts water to one part ethanol.

Shipping Paper Discrepancy

The shipping description used on the hazardous materials shipping paper (train consist) that was in the train crew's possession was UN1987, Alcohols, N.O.S., Class 3, PG II. This describes denatured fuel ethanol and is not the proper shipping description for undenatured ethanol. Placards displayed on each rail car listed UN Identification Number 1170, signifying undenatured ethanol. Emergency response information (required by 49 CFR 172.602) appended to the train consist described the hazards of UN1987 denatured fuel ethanol, not UN1170 absolute or undenatured ethanol.

The shipper confirmed that the lading on the accident train was undenatured ethanol UN1170. The Green Plains plant manager told investigators that the shipping documents were prepared at the company's headquarters in Omaha, Nebraska, and he could not explain the proper DOT shipping name discrepancy in the train consist.

On March 14, 2017, the Hazardous Materials Group visited the shipper's Superior, Iowa facility to review railcar loading and securement procedures and information about the shipment of ethanol as undenatured vs. denatured. The laboratory manager and the operations/shipping supervisor explained that some customers, particularly those who export the product, request the material be shipped as undenatured ethanol. The decision whether to ship as denatured or undenatured is made by Green Plains corporate headquarters in Omaha, Nebraska based on customer needs. The laboratory manager told NTSB investigators that undenatured ethanol requires the use of more robust steel cable-type seals for tank car valves and fittings, which is a process that Green Plains has adopted for both denatured and undenatured ethanol shipments. An additional logistical difference between shipping the two products is that undenatured ethanol is taxed at a higher rate than denatured ethanol.

The laboratory manager explained that when Green Plains Superior receives an order for an ethanol shipment, the Green Plains corporate headquarters provides loading tracking numbers and the customer's chemical specification requirements. As the cars are loaded, an ETX Intellifuels system controls the dispensing volumes, reporting gross and net gallons with temperature correction. The Intellifuels system produces a metered ticket that displays the shipping name in old DOT proper shipping name format: (PSN, UN ID #, PG), and identifies the material by default as UN1987 denatured fuel ethanol. This is the only product description that was programmed into the Intellifuels system 9 years ago and cannot be changed by the operator. The meter tickets containing the wrong hazardous materials description and tank car inspection sheets indicating the correct UN identification number for undenatured ethanol are forwarded to the Green Plains Omaha, Nebraska office. The Green

[8] T*raining Guide to Ethanol Emergency Response, Module 3: Chemical and Physical Characteristics of Ethanol and Hydrocarbon Fuels*, (Ethanol Emergency Response Coalition, 2007)

Plains logistics coordinator is then responsible for arranging shipments and preparing electronic data interchange (EDI) documents for the railroad.

FRA obtained EDI form 404 documentation indicating that on March 9, 2017, 09:02, the Green Plains logistics coordinator entered information for the train identifying the lading as UN1987 denatured fuel ethanol. The documents show he subsequently attempted to change the description to UN1170 undenatured ethanol on March 10 at 09:12, but that attempted correction was not accepted by the EDI system because the railcars were already in transportation (and the accident had already occurred).

In a June 8, 2017 Federal Railroad Administration (FRA) inspection report, an FRA hazardous materials inspector notified the Union Pacific Railroad that the carrier violated 49 CFR 174.26(b) because the train crew accepted the tank cars into transportation after failing to inspect each of the 98 tank cars at ground level for inconsistencies between the placard (UN1170, Ethanol, 3, PG II) and the shipping papers (UN1987, Alcohols, n.o.s., 3, PG II). On June 9, 2017, the FRA hazardous materials inspector similarly notified Green Plains Logistics that it violated 49 CFR 172.202 for releasing into transportation 98 tank cars with the railroad shipping papers incorrectly describing the hazardous materials as UN1987 Alcohols, n.o.s., 3, PG II. According to the FRA reports, local emergency responders attempted to determine proper response measures using the erroneous train consist. The report states that emergency response actions were delayed when different tank car placard information prompted emergency responders to reformulate their plan for evacuation, mitigation, and responder safety. The reports state that the FRA hazardous materials inspector informed the Union Pacific Railroad and Green Plains Logistics the matter would be referred to the Office of Chief Counsel for enforcement action.

Attachment 6: Bills of Lading Accident Tank Cars
Attachment 7: Safety Data Sheet Undenatured Fuel Ethanol
Attachment 8: Green Plains Electronic Data Interchange EDI 404 Summary Record
Attachment 9: Original EDI 404 Record March 9, 2017
Attachment 10: Attempted Correction to EDI 404 Record March 10, 2017
[redacted]

E. Hazardous Materials Released

Twenty (20) tank cars derailed in positions 21 through 40 in the train.[9] Eleven (11) of the derailed tank cars were breached from mechanical damage, while three (3) tank cars released product from only from leaking bottom outlets or thermal damage. A total of fourteen (14) cars released product that fueled a post-accident fire that burned for over 36 hours. The Union Pacific program manager for

[9] Union Pacific train consists list the rail cars from the rear of the train forward, and thus the shipping papers reflect the derailed tank cars as being in positions 80 through 61.

hazardous materials and response provided volumetric recovery data recorded by wrecking and remediation contractors for each tank car. Contractors recovered some amount of product from 8 of the breached tank cars (Table 1).

Table 1. Tank Car Loading, Outage Calculations, Volumes Recovered and Released

Line Number	UP Line Number	Car Number	Tank Capacity	Loaded Vol (Gross Gallons)	Net Gallons	Outage (% by vol)	Recovered Volume	Amount Released
21	80	DBUX 301674	30,060	28,893	28,801		14,200	14,693
22	79	TAEX 2893	29,953	28,880	28,800	0.0443 4%	2,250	26,630
23	78	TILX 199147	30,100	28,896	28,802	0.0431 4%	6,000	22,896
24	77	TCBX 198194	30,080	28,893	28,801	0.0425 4%	2,600	26,293
25	76	CTCX 732108	30,060	28,897	28,800	0.0419 4%	1,400	27,497
26	75	TILX 197694	30,120	28,896	28,801	0.0437 4%	0	28,896
27	74	DBUX 302834	30,090	28,886	28,798	0.0429 5%	0	28,886
28	73	DBUX 302746	30,070	28,921	28,799	0.0422 4%	28,921	0
29	72	TAEX 2909[10]	30,150	28,922	28,798		0	28,922
30	71	WCHX 30078	30,000	28,926	28,801	0.0422 4%	0	28,926
31	70	WCHX 30098	30,000	28,922	28,800		9,500	19,422
32	69	TILX 199819	30,090	28,920	28,798	0.0429 4%	15,250	13,670
33	68	TILX 195202	30,110	28,923	28,801	0.0434 4%	0	28,923
34	67	CTCX 731383	30,190	28,921	28,800	0.0460 5%	0	28,921
35	66	TILX 195386	30,060	28,919	28,800	0.0431 4%	28,919	0
36	65	CTCX 731997	29,953	28,908	28,799	0.0429 4%	0	28,908
37	64	TILX 197615	30,100	28,723	28,723	0.0435 4%	28,723	0
38	63	TILX 199168	30,080	28,711	28, 798	0.0435 4%	28,711	0
39	62	TILX 191239	30,060	28,723	28,798	0.0429 4%	28,723	0
40	61	DBUX 301606	30,120	28,715	28,800	0.0418 4%	28,715	0
		Unknown					1,800	-1800
TOTALS:				**577,395**	**547,120**		**225,712**	**351,683**[11]

[10] UMLER indicates TAEX 2909 replaced the original car number GATX 203812.

[11] This figure is based on less accurate estimates of volumes pumped to vacuum trucks, which are not equipped with accurate gauging devices. A more accurate release amount based on total frac-tank volumes was also calculated.

Union Pacific contractors transferred ethanol from four non-breached tank cars derailment (lines 61 to 64) to rail-worthy tank cars, which were returned to the shipper. Contractors transferred the remaining product from eight of the breached tank cars to on-site frac tanks for temporary storage.[12]

Based on frac tank recovery volumes, the amount of ethanol released in the accident was calculated as follows:

	577,395	gallons gross load received in 20 derailed tank cars
-	172,712	6 tank cars that did not release product
	404,683	balance 14 breached derailed tank cars
-	82,858	frac tank recovery volume (partial loads)
	321,825	gallons released = Approximately 322,000 gallons released

Upon completing ethanol transfer activities, the damaged tank cars were staged in the adjacent agricultural field east of the derailment site to facilitate the Hazardous Materials Group examinations.

Union Pacific Railroad contractors decontaminated the breached tank cars and cut them up for scrap metal disposal.

Attachment 12: Outage Calculations for Derailed Tank Cars

F. Shipper's Actions

Hazardous Materials Shipper's Actions - Shipment Preparation

Outage and filling limits are regulated by 49 CFR 173.24b, additional general requirements for bulk packages. Liquids such as ethanol must be loaded such that the outage is at least one percent of the total capacity of the tank car. The outage must be corrected to reference temperatures that depend on whether the tank car is insulated or equipped with a thermal protection system. The loading records indicate that the outages of the tank cars involved in this accident ranged between 4 and 5 percent.

The shipper does not calculate outage for each tank car. However, the shipper has determined that winter loading of 28,800 gallons per tank car (or 28,500 gallons after April 1) generally provides an outage of between 3% to 4.5%.

In accordance with 49 CFR 174.9, the shipper is supposed to conduct several safety and security checks prior to loading the tank cars and prior to offering the cars into transportation. The shipper's procedures for pre-inspecting tank cars prior to offering them into transportation consists of, among other things, the following:

[12] A frac tank, originally manufactured for use in the oil and gas drilling industry, is a large mobile temporary storage tank that is used to hold waste water and chemicals. A typical frac tank holds about 21,000 gallons.

- Tank shell free from dents, punctures, or any signs of leakage
- Legible stenciling
- Four placard holders in place
- Springs missing
- Wheel bearing bolts in place
- Cracks in bolster frame or cradles over wheel trucks
- Leakage from wheel bearing
- Defect card displayed on car
- Manway cover gasket in good shape
- Manway cover gasket replaced (cracked, broke, chunks missing)
- Manway cover bolts torqued to specification
- Liquid and vapor valve plugs tool tight
- BOV packing nut tightened
- BOV is closed and not leaking
- BOV handle secured with sealing pin
- Security seals applied
- Placard with UN ID number 1170 displayed on car

The shipper did not note any exceptions for the tank cars that derailed in this accident. However, the proper shipping name provided on the loading record (Alcohols, N.O.S., 3, UN1987, PGII) did not match the placard number recorded on the pretransport inspection sheet (UN1170).

On March 14, 2017, the Green Plains loading supervisor demonstrated tank car inspection procedures as the Hazardous Materials Group observed loading operations for two tank cars of undenatured ethanol. Except for the proper shipping name discrepancy noted on the inspection and loading documentation, the Group did not note any exceptions (see Section G of this report for further details regarding use of the incorrect shipping name for undenatured ethanol).

Attachment 13: Tank Car Loading and Pretransport Inspection Records

G. Denatured and Undenatured Ethanol

Ethanol Transportation Trends

The Environmental Protection Agency (EPA) Renewable Fuel Standard (RFS) program was created under the Energy Policy Act of 2005 amendments to the Clean Air Act. The RFS was further amended by the Energy Independence and Security Act of 2007 (EISA – Public Law 110-140). The EPA implements the program in consultation with the U.S. Department of Agriculture and the Department of Energy. The RFS program as a national policy that requires a certain volume of renewable fuel, such as ethanol, to replace or reduce the quantity of petroleum-based transportation fuel.

Section 202 of the EISA includes annual target volumes and requires the EPA to establish compliance obligations that refiners and importers must meet every year. The statutory target volume for total biofuel use increases from 24 billion gallons annually in 2017 to 36 billion gallons annually by 2022. However, in its December 14, 2015 final rule the EPA responded to marketplace constraints by establishing reduced finalized renewable fuel volumes for the years 2014 through 2016.[13] Nevertheless, the EPA final rule states that nearly all of the approximately 139 billion gallons of gasoline used as domestic transportation fuel contains 10 percent ethanol (E10). Railroads account for 60 to 70 percent of ethanol transportation, with about 334,000 tank car loads originated in 2014.[14]

The director of regulatory affairs for the Renewable Fuels Association (RFA) told NTSB investigators that ethanol industry has experienced significant recent growth in shipment of undenatured fuel ethanol as shown in Figure 3. She explained that the growth in undenatured ethanol shipments is mostly due to foreign markets in Brazil and southeast Asia in which end-users request the product without denaturant added. Unlike domestic ethanol producers, foreign ethanol producers typically do not denature their ethanol product.[15]

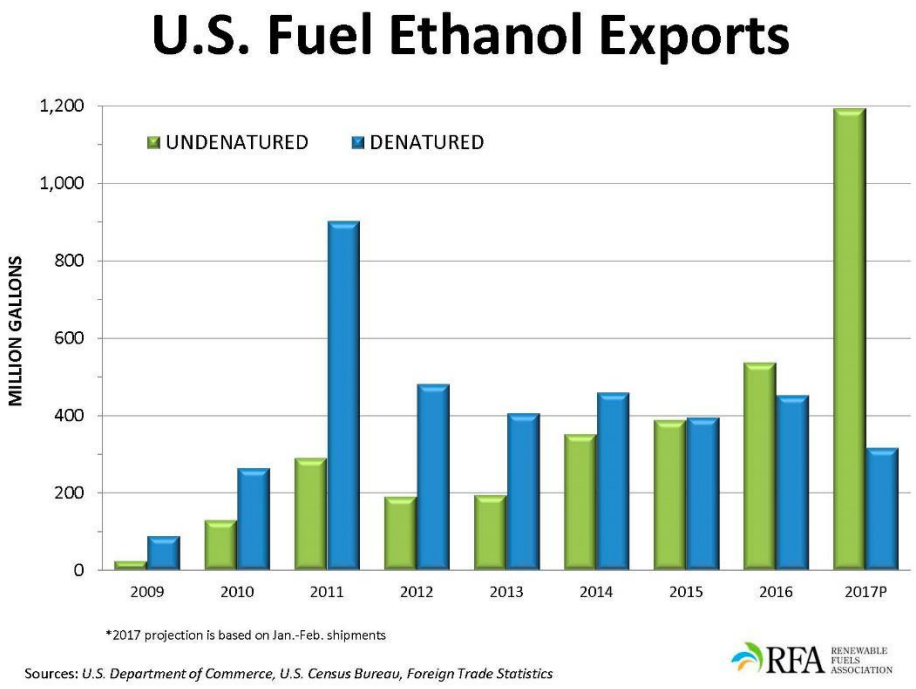

Figure 3: U.S. annual exports of denatured and undenatured fuel ethanol 2009 - 2017. Source: Renewable Fuels Association.

[13] *Renewable Fuel Standard Program: Standards for 2014, 2015, and 2016 and Biomass-Based Diesel Volume for 2017,* Environmental Protection Agency final rule (80 FR 77420, December 14, 2015).

[14] An overview of ethanol transportation volumes by rail is provided by the Association of American Railroads on its website at: https://www.aar.org/todays-railroads/what-we-haul?t=energyproducts, accessed July 11, 2017.

[15] *Enhancement and Growth Support Rule,* Environmental Protection Agency, Notice of Proposed Rulemaking (81 FR 80828, November 16, 2016).

Transportation Logistics and Accident Data

The RFA director of regulatory affairs explained that any decision to ship ethanol as undenatured is not constrained by logistics, but rather by regulatory disincentives given the Alcohol and Tobacco Tax and Trade Bureau (TTB) beverage tax requirements. Federal law requires that ethanol produced at an alcohol fuel plant (AFP) be restricted for use exclusively as a motor fuel.[16] Before proprietors may withdraw distilled spirits from an AFP, the spirits must be rendered unfit for beverage use, otherwise the TTB requires payment of distilled spirits taxes if the ethanol is diverted to beverage use. The TTB defines fuel alcohol as having been made unfit for beverage use by adding materials to distilled spirits that will preclude beverage use without impairing their quality for fuel use.[17] Formulas for completely denaturing alcohol to make it undrinkable and thus not subject to the beverage alcohol tax are provided in 27 CFR Part 21.

Under current RFS provisions, ethanol does not become a renewable fuel until a producer adds denaturant in accordance with TTB regulations at 27 CFR Parts 19-21. Only after a renewable fuel producer has denatured the ethanol can they generate renewable identification numbers (RINs) for it.[18]

Ethanol for use in motor fuel will generally be denatured with 2 – 5 percent gasoline or similar hydrocarbon.[19] According to the Ethanol Emergency Response Coalition, the addition of denaturant to ethanol depresses its flash point providing significantly more volatile vapor for the product to ignite in air. Compared to undenatured ethanol, which has a flash point of 55 degrees F, denatured fuel ethanol typically has a flash point of -5 degrees F.

In 2014, the Federal Railroad Administration compared data relating to thermal failures of tank cars involved in train derailments between 2006 and 2013 and concluded that denatured ethanol tank cars pose a greater risk of high-energy explosive events than tank cars carrying volatile crude oil grades when exposed to pool fires.[20] Comparing empirical data for post-accident pool fire damage such as thermal tears and tank fragmentation, the FRA found that the rate of tank car thermal failure in a pool fire was 15.5% for tank cars carrying denatured ethanol and 9.5% for crude oil.

In addition, Federal Railroad Administration, Office of Safety, Hazardous Materials Division staff director testified at an April 2014 NTSB Rail Safety Forum:

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[16] 26 U.S.C. 5181

[17] Rules for distilled spirits for fuel use are contained in 27 CFR Part 19.

[18] Renewable identification numbers (RINs) are credits used for tracking compliance and are the "currency" of the RFS program. RINs are generated when a fuel is produced and may be bought, sold, and traded amongst obligated parties (refiners and importers of gasoline) and domestic and foreign market participants.

[19] (Ethanol Emergency Response Coalition, 2007)

[20] Alexy, Karl, "*Comparative analysis of documented damage to tank cars containing denatured alcohol or crude oil exposed to pool fire conditions*," white paper, Office of Safety, Federal Railroad Administration, June 2014.

> When you look at the damage to the tank cars, and in this case, particularly tank cars that have had thermal ruptures, thermal tears, there have -- and then, I'm going to distinguish between just the thermal tear where you -- you know, it opens up partially, and an incident where there's enough energy to fragment the car. When we look at those, and of all the -- I think there have been approximately 31 tank cars that have experienced some type of thermal damage, and there have been, I think, 7 or 8 that have had -- that were violent ruptures or the ones where the tank car fragmented, all but one has been in ethanol service.[21]

Post-accident Fire in Graettinger, IA

The March 10, 2017, accident in Graettinger, Iowa is the first derailment with breached tank cars and post-accident fire involving a high-hazard flammable unit train transporting undenatured ethanol. Immediately following the derailment, a Union Pacific train crew member described his observations in the following radio communication with a dispatcher:

At 12:47 a.m.[22]

UP 5666: Yeah, we came apart. We've got tanks on fire behind us, over. Milepost 57.

Dispatcher: Milepost 57, train's in pieces, you got tank cars on fire?

UP 5666: That's correct. We had an explosion there behind us. I see multiple flames [phonetic] behind as we're pulling the pins stretching away from these cars, over.

On March 11, 2017, NTSB Investigators interviewed the accident train engineer and conductor.[23] The engineer stated that he felt a lurch forward from the brakes applying and saw a flash outside the cab window. He turned in his seat and saw the derailed cars and fire. The conductor said that both he and the engineer felt a forward lurch from the emergency air brake application. He looked back and saw a large fire ball rising into the sky and observed that the train had "broken apart."

The Graettinger fire chief was the first emergency responder to arrive on the scene about 01:09 a.m. on March 10. The fire chief told NTSB investigators that in sizing up the incident scene from a distance with binoculars, he observed "the fire seemed big, but could have been bigger." He said the released material was steadily burning, but there were no explosions. The fire chief said that he concluded the

[21] National Transportation Safety Board, "Rail Safety Forum: Transportation of Crude Oil and Ethanol," public hearing, Washington, D.C., April 22-23, 2014.

[22] The timeline for this accident was standardized to the locomotive event recorder (+3 minutes relative to the dispatcher's time). Thus, this conversation actually took place at 12:50 a.m.

[23] See the NTSB Operations Group factual report for details of the train operating crew interviews.

ethanol was not an explosive commodity based on his past training in ethanol emergency response. The fire chief also said that given the half-mile distance to nearest residences the emergency response efforts could therefore be focused on separating undamaged tank cars from those that were burning.[24]

Between March 11 – 13, NTSB investigators examined the damaged tank cars and did not identify any large thermal tears or other physical evidence of thermally-induced energetic tank failures. See Section J of this report for further tank car damage assessment details.

Attachment 14: Safety Data Sheet Denatured Fuel Ethanol
Attachment 15: Radio Transmission Transcript, March 10, 2017, 12:47 a.m.

H. Environmental Response

Center for Toxicology and Environmental Health Actions

On March 10, 2017, the Union Pacific Railroad contracted the Center for Toxicology and Environmental Health, LLC (CTEH) to initiate real-time air monitoring and air sampling support. Real-time air monitoring was established in the adjacent community and in work zones for worker protection. Air monitoring analytes included benzene, carbon monoxide, formaldehyde, atmospheric flammability, particulate matter (PM 2.5), and total volatile organic compounds. Between March 10 and March 11, stations were established in a 1 to 2-mile perimeter of the accident scene. No detections exceeding established action levels occurred within populated areas.

Arcadis, U.S., Inc. Actions

Union Pacific Railroad contracted Arcadis, U.S., Inc., to provide support to the derailment remediation efforts. These activities included collecting data to evaluate potential impacts to Jack Creek, implementing soil sampling and remediation, supporting ecological permitting, and preparing and submitting required reports to the Iowa Department of Natural Resources (Iowa DNR).

The Arcadis report to the Iowa DNR concluded that most of the released ethanol was thought to have been consumed by the fire due to its size, duration, and intensity.[25] The Arcadis report further characterized the level of ethanol released to the soils in the vicinity of the derailment as relatively low. Arcadis reported that dissolved oxygen monitoring and ethanol testing did not indicate significant impact to surface waters of Jack Creek.

[24] See the NTSB Emergency Response Group factual report for further details of the fire chief interview.
[25] *Written Report for Hazardous Conditions Union Pacific Railroad – March 10, 2017 Derailment Iowa DNR Spill Number 031017-JBV-0221, Graettinger, Palo Alto County, Iowa* (Arcadis U.S. Inc., April 10, 2017)

Surface Water Monitoring

Between March 10 – 15, Arcadis collected surface water dissolved oxygen (DO) data at locations upstream and downstream of the derailment site extending to the 360th Street bridge crossing, about 1 mile south of the derailment site to evaluate the potential impacts to the water quality of Jack Creek. Arcadis reported that the presence of ethanol had the potential to create a chemical oxygen demand in the creek waters that could have substantially decreased the DO causing stress on aquatic life. Arcadis reported downstream DO measurements of 9.81 mg/L to 18.68 mg/L, which were consistent with upstream measurements of 11.94 mg/L to 18.9 mg/L. Arcadis reported that the measured DO was above concentrations that would indicate adverse impact.[26] Technicians did not encounter any stressed aquatic life during the course of their monitoring activities.

Arcadis also continuously measured DO in surface water immediately downstream at the 300th Street bridge crossing while derailed tank cars were being removed from the creek on March 13. DO readings ranged from 11.47 mg/L to 18.90 mg/L throughout the area, which according to Arcadis, are above any concentration that would indicate adverse impact.

Arcadis also collected several surface water samples from the 300th Street bridge crossing on March 13 that it shipped to Pace Analytical Laboratories for ethanol analysis. Ethanol concentrations in water ranged from 80.3 mg/L to 3,230 mg/L. While the state of Iowa does not have a surface water quality standard specific to ethanol, the state has previously referenced New England Interstate Water Pollution Control Commission surface water benchmarks, which state that an ethanol concentration of 56 mg/L is sufficient to deplete dissolved oxygen in a small stream, and that a concentration of 564 mg/L is likely to be acutely toxic to aquatic life.[27] [28]

Contaminated Soil Removal

Arcadis submitted a soil sampling and removal plan to the Iowa DNR on March 12, 2017. Arcadis conducted soil sampling in the derailment site after tank cars were removed and before bridge and track reconstruction began. From March 13 through 15, soil samples were collected in a grid pattern to a depth of 4-feet below ground surface to characterize the ethanol impact. Arcadis screened the soil samples on-site using a photoionization detector (PID), and submitted them to Pace Analytical Services, LLC for laboratory analysis. Based on the PID screening, contractors excavated about 1,469

[26] State water quality standards are provided in Chapter 61 of the Iowa Administrative Code, which specify minimum dissolved oxygen levels of 5 to 7 mg/L depending on the waterway classification.

[27] A. Wolf, Iowa Department of Natural Resources, e-mail ("DNR Memo on UPRR Train Derailment") to P. Stancil, National Transportation Safety Board, June 30, 2017.

[28] *Health, Environmental, and Economic Impacts of Adding Ethanol to Gasoline in the Northeast States, Water Resources and Associated Health Impacts* (Lowell, Massachusetts: New England Interstate Water Pollution Commission, Volume 3. 2001).

tons of ethanol-contaminated soil to a depth of 0.5 to 4 feet, and transported it to the Northern Plains Regional Landfill in Graettinger, Iowa for disposal.

Attachment 16: CTEH Air Monitoring Summary, March 15, 2017
Attachment 17: Arcadis Emergency Response Activity Report to Iowa DNR, April 10, 2017

I. Derailed Tank Cars

Tank Car Specifications

Table 2 provides a summary of tank car specifications retrieved from the stencil, specification plate, or an UMLER report.

Table 2. Summary of tank car information.

LINE No.	UP No.	REPORTING MARK	BUILDER	BUILD DATE	OWNER	DOT SPECIFICATION	MATERIAL HEAD/SHELL	HEAD AND SHELL THICKNESS	Tank Size (gal)
21	80	DBUX 301674	ARI	4/1/2007	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,060
22	79	TAEX 2893	Trinity	2/18/2000	AEX The Andersons	111A100W1	A516-70/ A516.70	.4375	29,953
23	78	TILX 199147	Trinity	2/1/2008	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,100
24	77	TCBX 198194	Trinity	8/1/2007	SOXX SMBC Rail Services LLC	111A100W1	A516-70/ TC 128-B	.4375	30,080
25	76	CTCX 732108	ARI	3/31/2009	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,060
26	75	TILX 197694	Trinity	2/1/2008	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,120
27	74	DBUX 302834	Trinity	7/1/2007	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,090
28	73	DBUX 302746	Trinity	7/1/2007	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,070
29	72	TAEX 2909[29]	Trinity	5/19/2005	AEX The Andersons	111A100W1	A516-70/ 5167128	.4375	30,150
30	71	WCHX 30078	ARI	8/1/2003	WCHX Walter Haffner Company	111A100W1	A516-70/ TC 128-B	.4375	30,000
31	70	WCHX 30098	ARI	8/1/2003	WCHX Walter Haffner Company	111A100W1	A516-70/ TC 128-B	.4375	30,000
32	69	TILX 199819	Trinity	12/1/2007	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,090
33	68	TILX 195202	Trinity	5/1/2007	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,110
34	67	CTCX 731383	Trinity	9/1/2008	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,190
35	66	TILX 195386	Trinity	8/1/2007	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,100
36	65	CTCX 731997	ARI	3/31/2009	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,090
37	64	TILX 197615	Trinity	2/1/2008	SOXX SMBC Rail Services LLC	111A100W1	A516-70/ TC 128-B	.4375	30,110
38	63	TILX 199168	Trinity	1/1/2008	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,110
39	62	TILX 191239	Trinity	2/1/2005	TILX Trinity Ind. Leasing	111A100W1	A516-70/ TC 128-B	.4375	30,090
40	61	DBUX 301606	ARI	3/1/2007	CEFX CIT Group	111A100W1	A516-70/ TC 128-B	.4375	30,095

[29] UMLER indicates TAEX 2909 replaced the original car number GATX 203812.

Applicable Tank Car Regulations and Industry Standards

The HMR in 49 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 AAR Manual of Standards and Recommended Practices, Section C-Part III, Specifications for Tank Cars, Specification M-1002.

At the time the DOT-111 tank cars in the accident train were constructed, tank cars transporting ethanol could be fabricated of plate materials meeting the specifications that are outlined in 49 CFR 179.200-7. The tank cars involved in this accident were constructed from carbon steel plates. Specification 111 tank cars must be fabricated from TC 128 Grade B steel or A5l6-70 steel.[30] The specification requirement for DOT-111A100W1 requires a minimum plate thickness of 7/16-inch thickness.[31] At the time these tank cars were constructed, federal regulations did not require thermal protection, tank-head puncture resistance systems such as jackets or head shields, or the use of tougher normalized steel.[32]

Other hazardous materials regulations pertinent to loading and use of tank cars include:

- 173.24(b) - outage and filling requirements for bulk packaging. Liquids must be loaded with at least one percent outage of the total capacity of a tank car at the reference temperature of 115°F for a non-insulated tank.
- Part 180, Subpart F - qualification and maintenance of tank cars. Tank cars are required to successfully pass periodic inspections at a frequency determined by the type of tank car and the products transported. Such inspections include, but are not limited to, the following:
  - Internal and external visual inspection of the tank shell and heads for abrasion, corrosion, cracks, dents, distortions, defects in welds, or any other condition that makes the car unsafe for transportation;
  - Structural integrity inspections and tests, including transverse and fillet welds at certain locations on the tank using non-destructive testing techniques Thickness of tank shell and heads to within specified tolerances in 180.509 (g);
  - Testing of pressure relief devices.

PHMSA final rule HM-251 requires that after October 1, 2015, new tank cars manufactured for use in a HHFT must be constructed to the specification DOT-117, or 117P performance standard as specified in Subpart D–Specifications for Non- Pressure Tank Car Tanks. PHMSA final rule HM-251C further

[30] See 49 CFR 179.200-7.

[31] See 49 CFR 179.201-1 – Individual Specification Requirements

[32] See 49 CFR 179.201-1 and 49 CFR 173.31(b)(3) and (4) - In accordance with 49 CFR 173.31(b)(4), the tank cars that were involved in this accident were not required to have thermal protection systems. Only tank cars that are used to transport Hazard Class 2 and poison inhalation hazard materials are required by the Hazardous Materials Regulations to have thermal protection that conforms to the specifications of 49 CFR 179.18.

required that DOT-111 tank cars used in ethanol service after May 1, 2023 and CPC-1232 tank cars used in ethanol service after July 1, 2023 must be replaced with new specification DOT-117 tank cars, or existing tank cars that have been retrofitted to DOT-117R performance standards.[33] Final rule HM-251C mandates the use of DOT-117 compliant tank cars for the transportation of all Class 3 flammable liquids regardless of train composition and regardless of whether flammable liquids tank cars are assembled in a HHFT.

Retrofitted tank cars must be equipped with full height head shields, minimum 11 gauge jackets, thermal protection systems, top fittings protection, and an enhanced bottom outlet valve handle design to prevent unintentional opening in accidents.

Among the DOT 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 protective housing, minimum ½ inch thick;
- Enhanced bottom outlet handle design to prevent unintended actuation during a train accident;
- 286,000 lbs. GRL authorized.

Flammable Liquids Tank Car Fleet Composition

The Green Plains transportation and logistics vice president told NTSB investigators that the company selects tank cars according to market prices, which vary according to numbers leased and the lease duration. The lease agreements are full service contracts in which the railcar retains the lessor's reporting mark and the lessor is responsible for most of the maintenance and administrative record keeping. Tank cars are assigned by availability, usability, and potential weight restriction for servicing the railroad at each of the Green Pains plants. He stated that tank cars constructed to 286,000 pounds gross rail load (GRL), such as DOT-117 tank cars, may not be capable of full-capacity loading because of track infrastructure limitations on rail lines leading into some ethanol plants.[34]

The Green Plains transportation and logistics vice president told investigators that company management is fully aware of the applicable rules and the 2023 phase out deadline for DOT-111 tank cars, and thus the logistics team is tasked with ensuring compliance on behalf of the company. He stated that to ensure the fleet remains compliant, Green Plains has been negotiating replacement plans and the movement of tank cars into and out of the fleet during repair periods arranged by the lessors. He further stated:

[33] *Hazardous Materials: FAST Act Requirements for Flammable Liquids and Rail Tank Cars*, Pipeline and Hazardous Materials Safety Administration, Final Rule. 81 FR 53935, August 15, 2016

[34] Legacy DOT-111 tank cars not constructed to CPC-1232 standards are limited to 263,000 pounds gross rail load.

Based on being a public traded entity we are not inclined to divulge details of our conversion plans because it would put us in an undesirable position with the manufacturers/vendors we are currently in negotiations with. Green Plains fully intends on meeting the mandate as dictated by the law.

NTSB investigators examined the UMLER database records for each of the seven rail car fleet owners that leased to Green Plains tank cars used in the accident train. Table 3 provides the number of legacy DOT-111, CPC-1232, and DOT-117 tank cars in the respective overall fleets between 2016 and 2017.

Table 3: UMLER Tank Car Statistics by Owner, January 2016 vs. April 2017

Car Owner[35]		DOT-111A100W1	CPC-1232	DOT-117	DOT-117R
1	2016	3,397	200	0	0
	2017	2,975	200	0	0
	Change	-422	-	-	-
2	2016	10,022	12,325	930	4
	2017	9,352	11,710	2,549	270
	Change	-670	-615	+1,619	+266
3	2016	3,527	1,354	200	0
	2017	4,740	1,476	451	153
	Change	+1,213	+122	+251	+153
4	2016	4,761	4,916	100	0
	2017	5,868	4,926	100	8
	Change	+1,107	+10	-	+8
5	2016	698	0	0	0
	2017	673	0	0	0
	Change	-25	-	-	-
6	2016	16,174	9,154	100	114
	2017	16,096	8,958	3,390	612
	Change	-78	-196	+3,290	+498
7	2016	518	105	0	0
	2017	547	120	0	0
	Change	+29	+15	-	-

On April 19, 2017, the AAR assistant vice president of environment and hazardous materials (AVP hazardous materials) reported on the status of the North American flammable liquid tank car fleet as of December 31, 2016, including the progress being made to replace DOT-111 and CPC-1232 tank

[35] For the purposes of this report the tank car fleet owners were not identified by name.

cars with DOT-117 compliant tank cars.[36] He stated that the AAR has been tracking FAST Act compliance over the past year and intends to provide the AAR Tank Car Committee regular updates on the status of the flammable liquids fleet. The AAR AVP hazardous materials stated that between 2013 and 2015 there was an increase in the number of DOT-111 tank cars in the ethanol fleet, which the AAR believes is attributable to some tank cars being repurposed from the crude oil fleet. Meanwhile there has been a relatively small number of DOT-117 tank cars that have entered the ethanol fleet since PHMSA final rule HM-251 was published (Figure 4).

The AAR AVP hazardous materials further stated that there were about 30,300 legacy DOT-111 tank cars in ethanol service that must be replaced or retrofitted to specification DOT-117 by May 1, 2023, which equates to a replacement rate of about 400 cars per month if done on a continuous basis from January 2017 through the deadline. He cautioned ethanol shippers in attendance that they must not lose sight of the fact that while little progress has been made, their fleets must be fully DOT-117 compliant by the FAST Act deadline.

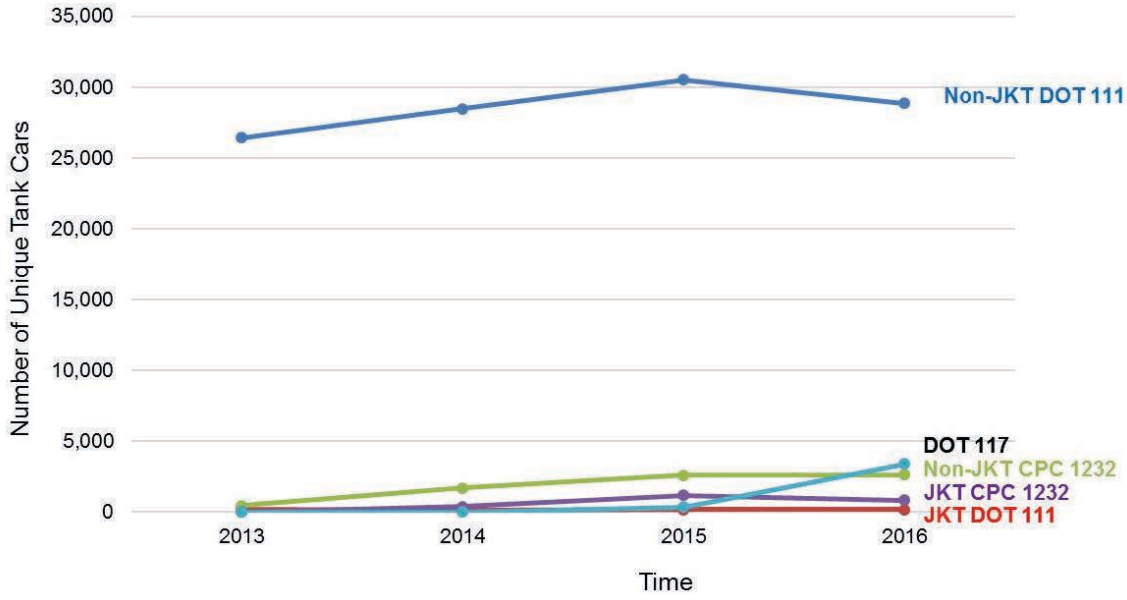

Figure 4: Number of Unique Tank Cars Making At least One Shipment of Ethanol by Year, 2013 - 2016. Source: Association of American Railroads, May 11, 2017.

On May 11, 2017, the AAR provided NTSB investigators its most recent figures for the status of the North American flammable liquid tank car fleet (as of March 31, 2017). The status report showed that of the 31,748 unique tank cars used to make at least one shipment of ethanol in 2016, only 3,385 were DOT-117 compliant (new and retrofitted tank cars). The number of DOT-117 tank cars used to transport ethanol increased during first quarter of 2017 to 4,936. Over the same period (2016 vs. first

[36] R. Fronczak, "Status of the North American Flammable Liquids Fleet," presentation to the Association of American Railroads Tank Car Committee, April 19, 2017, Atlanta, Georgia.

quarter 2017), AAR figures show the number of legacy DOT-111 tank cars in ethanol service dropped from 29,045 to 23,641 tank cars.

Attachment 18: AAR Statistics Status of Flammable Liquid Tank Car Fleet as of March 31, 2017

J. Tank Car Inspection

The orientation of the tank cars following the derailment is indicated in Figure 5. On March 11, 12, and 13, 2017, the Hazardous Materials Group entered the derailment scene and collected observations relative to the tank car accident performance, car-to-car impacts, and other impacting objects. Following transloading operations, the wrecking contractor, Hulcher Services, moved the tank cars from the right-of-way and staged them in a nearby farm field.

See Attachments 19 and 20 to this report for additional tank car examination details and damage summaries.

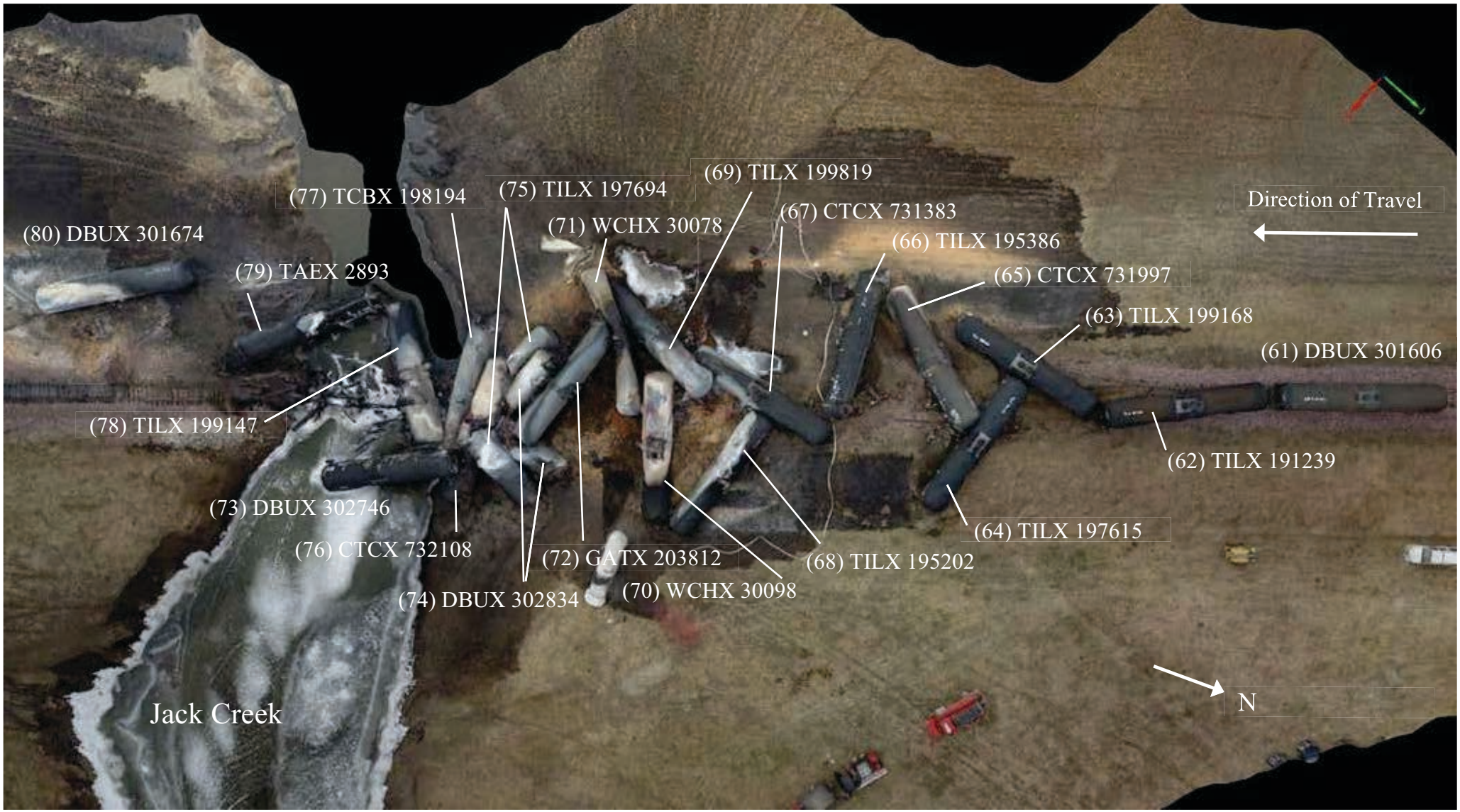

Figure 5: Derailment Scene and Tank Car Identification

Hazardous Materials Group Tank Car Observation Summary

Line 80: DBUX 301674

- The car came to rest on the south side of the trestle, about one car length west of the track. The car was resting on its left side, about 9 o'clock with its A-end leading;
- The left side of the tank was scorched about half the tank diameter leaving a ring residue in the paint;
- The top fittings housing cover was broken away, but still attached to the hinge;
- The vapor valve was detached from the threaded hole in the multihousing fittings flange but it was still chained to the plate. The vapor valve pipe threads were mashed (Figure 6);
- The right of way bank was eroded opposite of the multihousing missing valve opening;
- The pressure relief device throat was caked with mud;
- The right side of the shell was buckled about 3 o'clock in Rings 2 and 3.

Figure 6: DBUX 301674, in-situ (left), multihousing flange with missing vapor valve (right), March 11, 2017.

Line 79: TAEX 2893

- The car came to rest on its right side, with the B-end in the creek (Figures 7 and 8);
- Bottom outlet nozzle extension was torn off and the bottom outlet valve was open. First responders used a wooden plug to seal the valve;
- The B-end draft sill was bent to the right more than 90 degrees.

Figure 7: TAEX 2893, in situ (left), and in staging area (right) with plugged bottom outlet nozzle, March 11, 2017.

Figure 8: TAEX 2893 and TILX 199147, in situ, March 11, 2017.

Line 78: TILX 199147

- The car came to rest on its right side, with the A-end in the creek, B-end elevated and resting on CTCX 732108;
- A gouge and dent lead to a rectangular puncture in the A-end head. The A-end head sustained two punctures about 4 o'clock. The gouge originated from the head pad area. The punctures were about the size and shape of a coupler (Figure 9);
- The B-end head sustained a rounded dent covering the entire head surface;

- The bottom outlet valve nozzle was sheared away, the operating handle was missing, the valve was found closed.

Figure 9: TILX 199147 A-end head puncture, March 11, 2017.

Line 77: TCBX 198194

- The car came to rest on its right side, parallel to the north side of Jack Creek;
- The A-end head sustained a rectangular 8x22-inch puncture between the center line and draft sill (Figure 10).

Figure 10: TCBX 198194, A-end head puncture, staging area, March 13, 2017.

Line 76: CTCX 732108

- The car came to rest on its right/top side as the B-end was leading (Figure 11). The car was resting parallel to and on the north bank of Jack Creek;
- The tank shell sustained an irregular hole about 28x16 inches, A-L, Ring 5, about 11 o'clock;
- The tank shell sustained an irregular 10 ft. tear/hole in Ring 3 below the longitudinal seam;
- The vapor valve was missing. The liquid valve was broken away from the multihousing fittings flange, but remained attached to a chain.

Figure 11: CTCX 732108 in staging area, breaching damage circled March 13, 2017.

Line 75: TILX 197694

- The tank fractured in two pieces about mid-section and released all contents (see Figure 13). The fractured tank sections were separated about 20-feet in the pileup.

Line 74: DBUX 302834

- The tank fractured in two pieces and flattened about mid-section releasing all contents (Figures 12 and 13);
- A flap of shell material projecting outward from one fractured tank segment contained the pressure relief device;
- The B-end head sustained a 12 x 6-inch puncture about 3 o'clock.

Figure 12: DBUX 302834, two halves of fractured tank car, staging area, March 12, 2017.

Figure 13: TILX 197694 and DBUX 302834 in situ, March 11, 2017.

Line 73: DBUX 302746

- No point of release or breaching damage was observed;
- The car came to rest on its right side with the B-end in the creek and A-end elevated 45 degrees and resting upon CTCX 732108 (Figure 14).

Figure 14: DBUX 302746, in situ, March 11, 2017.

Line 72: GATX 203812 (TAEX 2909)

- The car came to rest on its right side with the B-end leading and in contact with DBUX 302834;
- The B-end head sustained an 8 x 8-inch square puncture right of the brake wheel within a rounded dent (Figure 15);
- The B-end coupler top shelf was broken off;
- An upward dent in the tank bottom was centered on the bottom outlet valve. Skid protection structure was bent upward exposing the bottom outlet valve;
- The bottom outlet valve nozzle was sheared away and the operating handle was missing. The valve was found in the closed position;
- The A-end head sustained a rounded dent, with the head pad fillet weld cracked at edge of the dent.

Figure 15: GATX 203812 / TAEX 2909, punctured B-end head (left) and bottom dent over the bottom outlet valve (right), staging area, March 12, 2017.

Line 71: WCHX 30078

- The car came to rest between the A-end head of GATX 203812 and the A-end of TILX 199819;
- The tank shell was crushed inward on the left and right sides of Ring 5, with both sides of tank nearly touching;
- The shell sustained a tear in the belly of the tank, 18 feet by 8 feet;
- The shell sustained a 1 to 2 ft. wide rectangular longitudinal shell tear at the left side length of Ring 6, extending into 5 o'clock region of A-end head (Figures 16 and 17).

Figure 16: WCHX 30078 shell fracture (left) and head-shell tear (right), staging area, March 12, 2017.

Figure 17: WCHX 30078 in situ, March 11, 2017.

Line 70: WCHX 30098

- The car came to rest upright with B-end facing west and A-end head plowed into the soil;
- On March 11, flame continued to burn from the pressure relief valve and manway. The multihousing cover was not mechanically damaged;
- The bottom outlet valve was leaking, nozzle was sheared off, and the operating handle did not open;
- Paint on the top half of car was scorched, leaving a ring pattern in the paint (Figure 18);
- One manway I-bolt was missing and two button rivets were missing;
- The 8 o'clock edge of B-end head was gouged, but head was not penetrated.

Figure 18: WCHX 30098 staging area (left), leaking bottom outlet (right), March 12, 2017.

Line 69: TILX 199819

- The car came to rest upright;
- The left side A-end head sustained a deep rounded dent;
- The shell at Ring 6 sustained a cut about 96 inches by 120 inches from contact with the head of adjacent tank car CTCX 731383. Shell deformation adjacent to the hole and extending into Ring 5 was about 6 ft. by 10 ft. (Figure 19);
- The bottom outlet valve nozzle sheared off, the operating handle was missing, and the valve was sealed. The bottom skid protection structure was damaged leaving the bottom outlet valve exposed;
- The B-end draft sill fractured at the head brace and was missing from car, along with the coupler;
- Parent metal stress cracking occurred in the head right of the B-end head pad. The head pad fillet weld did not fracture.

Figure 19: TILX 199819 A-end shell tear, staging area, March 12, 2017.

Line 68: TILX 195202

- The A-end was leading and the car came to rest with the head plowed into soil and the tank tilted to the left side;
- The shell in Ring 1 was buckled;
- A small 18-inch thermal tear was centered within a 12-inch outward bulge in Ring 2 (Figure 20);
- The bottom outlet valve operating handle was damaged, the bottom outlet valve was open. Investigators were uncertain whether the valve was manipulated during wreckage movement, since the valve packing was thermally damaged leaving the valve handle free to move easily;
- Paint was scorched across the left side and around top fittings and bottom outlet valve area leaving a ring pattern in the paint.

Figure 20: TLX 195202 Thermal tear (left circled) and open bottom outlet (right), staging area, March 12, 2017.

Line 67: CTCX 731383

- The car came to rest vertical with the A-end leading;
- The shell sustained a rectangular puncture on left side, with flap of steel pushed inward above the bottom outlet valve. The shell fracture ran about 24 inches along the bottom of car on the A-end side of the skid protection (Figure 21);
- The right half B-end head sustained a severe rounded dent with a 12-16-inch fracture on knuckle radius, about 3 o'clock;
- The bottom outlet valve was partly open and the operating handle was missing;
- A-end head from impact with TILX 165386 resulted in stencil transfer;
- The bottom third of A-end head was creased.

Figure 21 CTCX 731383 shell puncture (left circled) and B-end head fracture (right circled), staging area, March 12, 2017.

Line 66: TILX 195386

- The car came to rest on its right side, B-end down;
- No product was released from this car;
- The bottom outlet valve nozzle was undamaged. The operating handle was damaged but pinned in place;
- The lower half of the A-end head sustained a rounded dent;
- A-end head pad fillet weld separated across outboard end of the headpad adjacent to a deep dent in the head. No crack was observed in head parent metal;
- Stencil transferred from impact with CTCX 731383 to the left side of the A-end head;
- The top fittings housing cover was thermally damaged and the throat of pressure relief valve showed signs of heat exposure.

Figure 22: TILX 195386, top fittings (left) and A-end head pad separation (right circled), staging area, March 12, 2017.

Line 65: CTCX 731997

- The AEI report indicates the A-end was leading as the car came to rest on its right side with the A-end plowed into soil;
- A gouge led to a 2-inch tear on the A-end head about 6 o'clock;
- The A-end head sustained an 8-inch tear about 10 o'clock.
- The A-end head sustained an 8-inch crack across the head-to-shell weld underneath deeply folded head material, about 7 o'clock;
- The right half of the A-end head sustained a 3-4 ft. deep dent;
- The B-R bolster was bent toward the A-end;
- The B-end head sustained a rounded dent in the lower center about 6 o'clock;
- The bottom outlet valve operating handle was closed and pinned in place. The nozzle adaptor was sheared off and the valve was closed.

Figure 23: CTCX 731997 A-end head breaching damage (left and right circled), staging area, March 12, 2017.

Line 64: TILX 197615

- The car came to rest upright with the A-end downhill and leading;
- No product released from this car;
- The A-end head sustained a deep 24-inch long gouge and rounded dent about 8 o'clock;
- The bottom outlet valve operating handle was broken away. The valve remained closed.

Figure 24: TILX 197615 gouge to A-end head (arrow), March 12, 2017.

Line 63: TILX 199168

- No product was released from this car;
- The bottom outlet valve operating handle was damaged;
- Minor fire damage was noted at BL corner of the tank.

Line 62: TILX 191239

- The car was re-railed and removed from scene. No lading released.

Line 61: DBUX 301606

- The car was re-railed and removed from scene. No lading released.

Attachment 19: Tank Car Damage Report
Attachment 20: Tank Car Damage Assessment Summary Spreadsheet

Paul L. Stancil
Senior Hazmat Accident Investigator

Attachments

Attachment 1: Green Plains Superior, IA Railcar Count – Denatured vs. Undenatured Shipments

Attachment 2: Green Plains Superior Transfer Record and Inventory, Train UGGKOT 09

Attachment 3: Train Consist UEGKOT 09

Attachment 4: AEI Report UEGKOT 09 Estherville East, March 10, 2017

[redacted]

Attachment 6: Bills of Lading Accident Tank Cars

Attachment 7: Safety Data Sheet Undenatured Fuel Ethanol

Attachment 8: Green Plains Electronic Data Interchange EDI 404 Summary Record

Attachment 9: Original EDI 404 Record March 9, 2017

Attachment 10: Attempted Correction to EDI 404 Record March 10, 2017

[redacted]

Attachment 12: Outage Calculations for Derailed Tank Cars

Attachment 13: Tank Car Loading and Pretransport Inspection Records

Attachment 14: Safety Data Sheet Denatured Fuel Ethanol

Attachment 15: Radio Transmission Transcript, March 10, 2017, 12:47 a.m.

Attachment 16: CTEH Air Monitoring Summary, March 15, 2017

Attachment 17: Arcadis Emergency Response Activity Report to Iowa DNR, April 10, 2017

Attachment 18: AAR Statistics Status of Flammable Liquid Tank Car Fleet as of March 31, 2017

Attachment 19: Tank Car Damage Report

Attachment 20: Tank Car Damage Assessment Summary Spreadsheet