National Transportation Safety Board

Railroad Accident Brief

CSXT Petroleum Crude Oil Train Derailment and Hazardous Materials Release

Accident No.:	DCA14FR008
Location:	Lynchburg, Virginia
Date:	April 30, 2014
Time:	1:54 p.m. eastern daylight time
Train:	CSXT Train K08227
Railroad:	CSX Transportation (CSXT)
Property Damage:	$1,224,000
Injuries:	0
Fatalities:	0
Type of Accident:	Derailment with hazardous materials and fire

The Accident

On April 30, 2014, at 1:54 p.m. eastern daylight time, 17 CSX Transportation (CSXT) tank cars on petroleum crude oil unit train K08227 derailed in Lynchburg, Virginia.[1] Three of the derailed cars were partially submerged in the James River. One was breached and released about 29,868 gallons of crude oil into the river, some of which caught fire. (See figure 1.) No injuries to the public or crew were reported. At the time of the accident, it was cloudy and raining lightly; the temperature was 53° F. The CSXT estimated the damages at $1.2 million, not including environmental remediation.

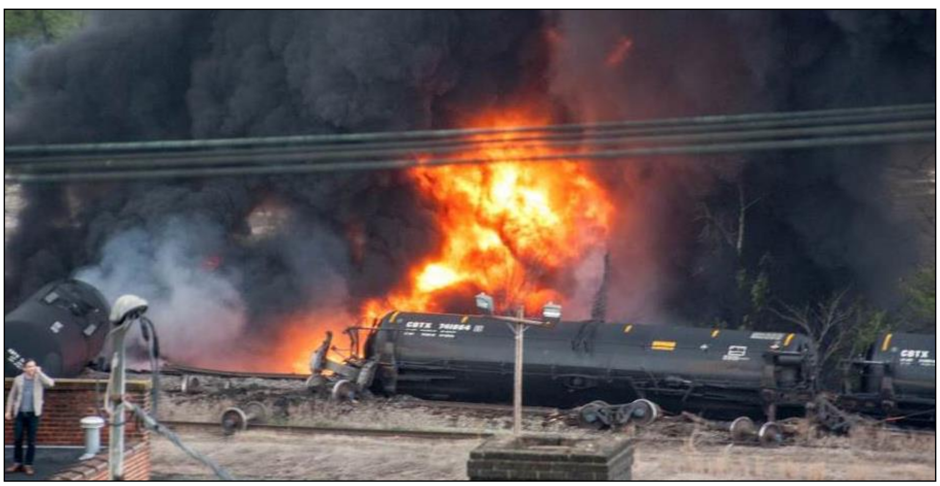

Figure 1. Accident scene**.**

[1] All times in this brief are eastern daylight time.

A "unit train" is a train in which all railcars carry the same commodity and have the same origin and destination.

The train consisted of two locomotives, one buffer car, and 104 tank cars loaded with crude oil.[2] It was 6,426 feet long with 14,107 tons trailing the locomotives. According to the railroad timetable, the train was traveling eastbound on main track 2 on the CSXT James River Subdivision.[3]

On April 30, 2014, the train's crew—an engineer and a conductor—reported for duty at 9:15 a.m. in Clifton Forge, Virginia; their final destination was Yorktown, Virginia.

The crude oil in the tank cars was from the Bakken region of North Dakota. The US Department of Transportation (DOT) has designated crude oil as a hazardous material subject to the hazardous materials regulations in Title 49 Code of Federal Regulations (CFR).4

The derailment occurred milepost (MP) CAB 146.45 on main track 2. There were no speed restrictions in effect near the derailment site; however, from MP CAB 146.9 to MP CAB 146.3, the permanent maximum authorized speed was 25 mph on both main tracks because of the track curvature. Event recorder data show the train was traveling at 24 mph at the time of the derailment.

Based on data from the locomotive event recorder, the train experienced an emergency brake application at 1:54 p.m. The crew said they saw a very large amount of smoke about 30 cars back from the locomotive. They radioed that there was an emergency and then notified the train dispatcher and the Lynchburg yardmaster. Fearing an explosion, the crew jumped from the locomotive, leaving the train consist and personal belongings behind.[5] They walked to the nearest grade crossing where they met a CSXT signal maintainer who heard the emergency radio transmission; the signal maintainer drove them to a nearby CSXT yard.

Emergency Response

The derailment resulted in a large fire along the James River. The Lynchburg Fire Department ordered the evacuation of about six blocks along the riverfront and south of the derailment area, affecting about 350 residents and 20 businesses. (See figure 2.)

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[2] A buffer car is a car that is not carrying hazardous materials that is placed between locomotives and occupied cabooses and cars containing hazardous materials to separate the crew from rail cars carrying hazardous materials. See 49 *Code of Federal Regulations (CFR)* 174.85.

[3] All directions in this report are based on the railroad timetable.

[4] 49 *CFR* 172.101, Purpose and Use of Hazardous Materials Table.

49 *CFR* 171.1, Applicability of Hazardous Materials Regulations (HMR) to persons and functions.

[5] The train consist is a list and description of all locomotives and railcars including car lengths and tonnage, a train profile (graph illustrating tonnage distribution), and shipping papers for hazardous materials.

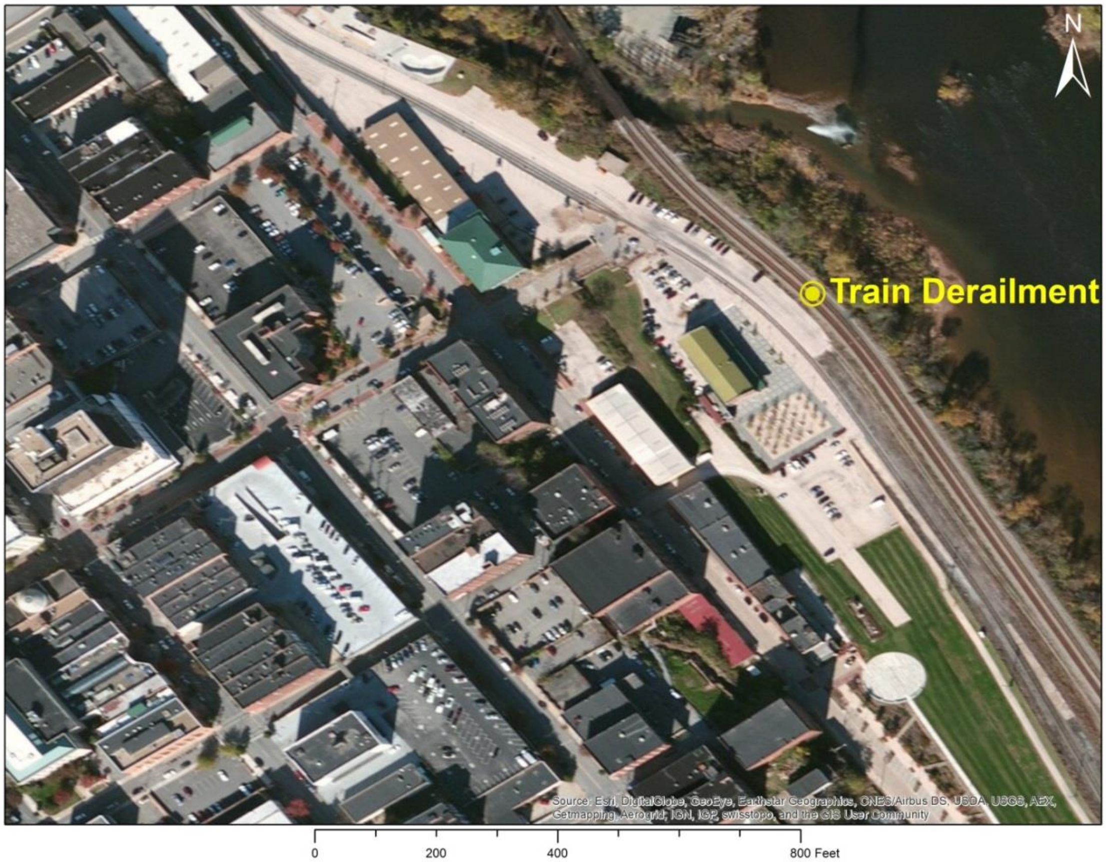

Figure 2. Derailment site in Lynchburg, Virginia.

Immediately after the accident, the city received numerous 911 calls. The Lynchburg Fire Department established an incident command post near the intersection of 9th and Jefferson streets. The CSXT Public Safety Coordination Center in Jacksonville, Florida, faxed a copy of the train consist, including the shipping papers, to the Lynchburg Communications Center. Emergency personnel quickly determined the tank car contained crude oil from the hazardous materials placards on the tank cars.[6]

Firefighters allowed the fire burn as they cooled the tank cars with water. The fire was out by 4 p.m., and the evacuation order was lifted by 5 p.m.

Signal System

Operating rules, timetable instructions, and signal indications from a traffic control system controlled by a train dispatcher in Huntington, West Virginia, govern train movements on the CSXT James River Subdivision.

[6] Shippers affix internationally recognized United Nations (UN) numbers on placards to identify hazardous materials; UN 1267 denotes a shipment of crude oil.

Postaccident testing determined the signal system was operating as intended and in accordance with federal regulations. Recorded signal data showed the train crew was operating on permissive signals.[7] No track anomalies were identified before the accident that would have either disrupted the track circuit or resulted in an alert to the operations center in Huntington, West Virginia.

Mechanical Inspection

The locomotives, the buffer car, and the first 34 tank cars behind the locomotives did not derail. Shortly after the accident, CSXT personnel moved the 34 non-derailed cars and the locomotives a short distance from the derailment site and fire. NTSB investigators inspected the locomotives and cars and witnessed airbrake testing. No defects were noted, and the brakes applied and released as designed. The required Federal Railroad Administration (FRA) mechanical inspections were current with no recorded defects.

Hazardous Materials

Petroleum Crude Oil

Petroleum crude oil is a complex combination of hydrocarbons that may contain small amounts of nitrogen, oxygen, sulfur, and trace amounts of heavy metals. It is generally a dark yellow-to-brown or greenish-black liquid with a hydrocarbon odor. Crude oil is a natural product with chemical and physical properties that can vary widely depending on the source and extraction method; it is a flammable liquid. The crude oil in this train was shipped as a class 3 flammable liquid, packing group I.

Wreckage Description

The derailed cars were located in positions 35 through 51 from the head end of the train (not including the two locomotives). Fourteen were built to the standard outlined in the Association of American Railroads (AAR) Casualty Prevention Circular (CPC) 1232; three were cars built to the DOT-111 standard for cars manufactured before October 2011.[8]

Only tank car CBTX 741712 in position 44 was breached. It released its contents, and the contents caught fire. The tank cars in positions 43 and 46 were exposed to the fire, but they were not breached. (See figure 3.) All three met the CPC 1232 standard.

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[7] A permissive signal is any signal other than a stop signal.

[8] In 2011, the AAR issued Casualty Prevention Circular CPC-1232 that outlined industry-mandated safety requirements for additional safety equipment on DOT-111 tanks ordered after October 1, 2011, that would be used in ethanol and petroleum crude oil transportation service.

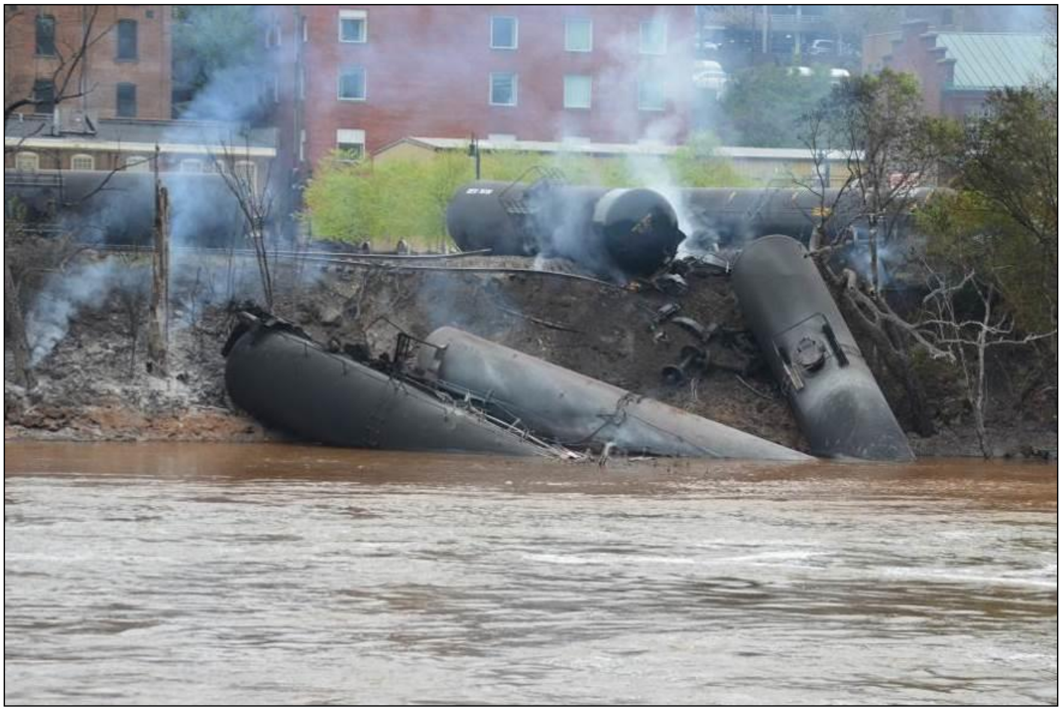

Figure 3. Smoldering, derailed tanks cars on the bank of the James River.

Tank Car Damage

NTSB investigators inspected all derailed tank cars, and samples were cut from the car that was hanging over the riverbank (CBTX 741720) and the breached tank car and shipped them to the NTSB materials laboratory in Washington, DC, for examination. Most of the damage to the car that was hanging over the riverbank occurred on the right side of the tank, particularly to the A end of the right body bolster.[9] The lower portion of the body bolster web was deflected toward the A end, while the upper portion—constructed out of solid, 2-inch thick steel—was partially deflected. (See figure 4.)

[9] The handbrake is usually located on the "B" end of a rail car. The A end of the rail car is opposite the B end.

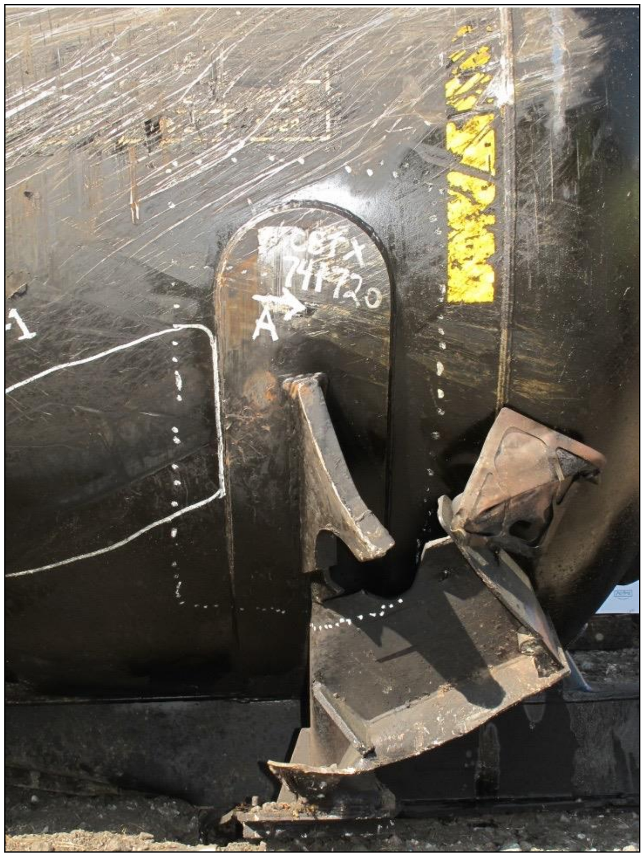

Figure 4. Right body bolster, A end, of CBTX 741720.

The tank car in position 44, CBTX 741712, had an approximately 95-inch long tear on the right side of its shell (tank car wall) that ran through two shell rings.[10] (See figure 5.) The tear occurred below the centerline. The NTSB examination indicated that an object scraped the shell of the tank car and tore into the shell at the longitudinal seam weld between two rings, producing two coiled rolls of metal that extended into the inside of the tank.

[10] Tank car shell rings are the welds that connect shell cylinders together to create a single tank.

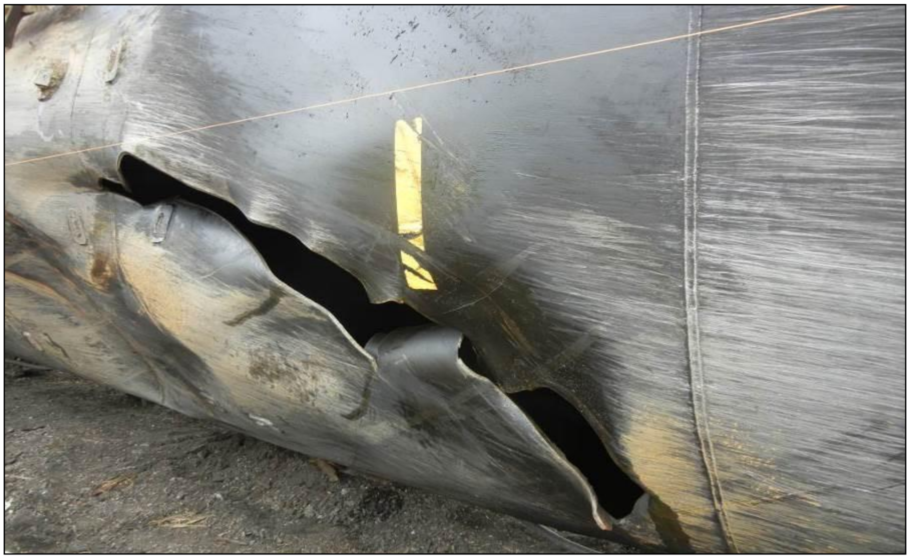

Figure 5. Tear in shell of tank car CBTX 741712.

Track and Engineering

MP numbers decreased in an eastward direction. There was an undulating grade between MP CAB 147.05 and MP CAB 146.45 and the train traveled through a series of curves with varying superelevation and a section of tangent or straight track.[11] The point of derailment was in a 7.24-degree, right-hand curve with 0.82 inches of superelevation.

At the point of derailment, the track had a mixture of 132- and 141-pound continuous welded rail with standard wooden crossties, spaced 20 inches on center (nominal).[12] The manufacturer's label on the rail at the point of derailment was 132 RE Nippon, 1990. Investigators identified no defective crossties in the undisturbed portion of track near the derailment site. Double shoulder tie plates bound the rail to the crossties, fastened with cut spikes, hairpins, screw lags, and elastics fasteners applied uniformly to the gage and field sides of the rail.

CSXT inspected and maintained the main track on this portion of the James River Subdivision to FRA *Track Safety Standards* for Class 2 and 3 tracks.[13]

[11] Superelevation is a measurement, generally in inches, of the relative difference in height between the top rail surface (tread portion of a railhead) of the inside (low rail of a curve from the tread portion of the railhead of the outside (high) rail. The high rail is "elevated" in relationship to the low rail or assigned a specific amount of superelevation based upon the amount of curvature and the maximum authorized speed. The tighter degree of curvature (increased degree of curvature) or higher operating speed or a combination of those factors progressively requires increased amounts of superelevation. A low and high rail would not have a need for superelevation if the degree of curvature were slight (a long sweeping curve) and the operating speed was low, say 10 miles per hour.

[12] The weight of rail is determined by measuring the weight (in pounds) of a 3-foot section of a rail.

[13] Class of track is defined at 49 *CFR* Part 213.

Identification of Point of Derailment

NTSB investigators recovered rail pieces from the derailment area and inventoried, measured, and documented each piece; they then ordered the pieces in the same order in which they were installed. Following the reassembly, investigators agreed that the wheel marks found on the north rail and the path of the derailed equipment indicated that the point of derailment was MP CAB 146.45.

There was a break in the railhead about 30 inches east from the rail end held in place within a set of joint bars.[14] The placement of the joint bars was a remedial action taken by the CSXT to repair an in-service rail failure found in January 2014—more than 3 months before the accident. Investigators observed and documented markings on the inside (or gage side) of the rail joint bar that was broken. Investigators found the outside rail joint bar bent but not broken.

The rail break immediately east of the joint bar location exhibited slight rail end batter on the trailing fracture edge and slight rail end batter on the receiving rail fracture edge (fracture edge in direction of travel).[15] The only set of fracture faces exhibiting trailing or receiving rail end batter were those associated with the reverse detail fracture located about 30 inches from the end of rail joint bars at the service rail failure that occurred in January.[16]

Reverse Detail Fracture

The derailment occurred at a sudden break of a rail originating from a reverse detail fracture on the gage corner of the railhead of the high rail in the curve.

A CSXT contractor performed ultrasonic testing in the area of the derailment the day before the accident.[17] Investigators reviewed the ultrasonic test data for the failure location. The data confirm that the test equipment functioned properly and responded to known rail features that would normally be detected by the ultrasonic test probes within the area of the failed rail.

The data showed defects discovered during the ultrasonic testing including a 20 percent transverse detail fracture; this was noted as number 151 on Sperry report number 119A, dated April 29, 2014.[18]

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[14] A joint bar is a formed steel bar used in pairs to join the ends of rails in a track.

Railhead refers to the top section of the rail, the highest part of the rail profile, and the top surface where the wheels of the rail cars roll.

[15] Rail end batter results when a rail breaks and exposes the fracture face to wheel impact from rolling stock.

[16] A reverse detail fracture is a progressive transverse fracture normally originating at the bottom corner of the gage side of the rail head. The origin is a stress riser associated with a notching condition on the cold rolled lip located on the bottom corner of the rail head.

[17] 49 *CFR* 213.235 requires internal rail inspections in addition to other types of inspections. Ultrasonic testing is a non-destructive volumetric examination technique used on steel to identify subsurface indications, such as cracks or voids.

[18] A transverse detail fracture is a progressive fracture originating at or near the surface of the rail head and should not be confused with traverse fissures, compound fissures, or other defects which have internal origins. Detail fractures may arise from shelling, head checks, or flaking. Refer to 49 *CFR* 213.337.

The size of a rail defect determines if mitigation is required by FRA regulation. The suspected rail defect that failed at the point of derailment was a 5 percent reverse detail fracture. Historically, regulations have not considered 5 percent reverse detail fractures to be a defect subject to complete failure prior to progressing to a larger size. These types of defects cause a stress concentration on the surface of the rail and may cause a complete rail failure at a much smaller size than typical detail fractures.[19]

Rolling Contact Fatigue

Rolling contact fatigue results from the cumulative effects of railhead wear and rail surface conditions, such as shelling, head checks, or flaking.[20] The detrimental effects of rolling contact fatigue can occur before a worn railhead profile or side wear is noted. Rail wear on the gage corner and side of the rail are easier to find and manage; however, the detection of fatigue in the lower corner of the gage face of the rail is more difficult. That part of the railhead it not easily scanned by ultrasonic equipment, and a regulatory remedial action was not mandated to address these flaws.

The FRA *Track Safety Standards* do not address this type of rail defect at the size that failed in the Lynchburg accident (5 percent reverse detail fracture).[21] The FRA remedial action chart addresses transverse detail fractures, but does not mandate remedial action until the defect is 20 percent or four times the size of the defect that caused this derailment. At that time, the railroad owner would be required to reduce speed to no more than 30 mph and apply joint bars within 20 days to the defective rail condition.

Postaccident Actions

CXST

Prior to the Lynchburg accident, if a transverse detail fracture had been 20 percent of the cross-section of the rail head, CSXT engineering standards required that the defective rail be changed out within 5 days or joint bars be installed to the rail at the site of the defect. Since the ultrasonic testing data indicated a transverse detail fracture near the location of the derailment, CSXT planned to replace the rail on May 1, 2014. Since the operating speed for that area was 25 mph, the rail defect did not require a speed restriction in accordance with CSXT maintenance procedures or FRA regulations.

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[19] A stress concentration, often called a stress riser, is a location in an object where stress is concentrated.

[20] *Shelling* is a progressive horizontal separation that may crack at any level on the gage side, generally at the upper gage corner. It extends longitudinally—not as a true horizontal or vertical crack, but at an angle related to the amount of wear. *Flaking* is a progressive horizontal separation on the running surface of the rail near the gage corner, with scaling or chipping of small slivers. Flaking should not be confused with shelling, as flaking takes place only on the running surface near the gage corner of the rail and is not as deep as shelling. *Head checks* are transverse surface cracks on the gage corner of rails resulting from cold working of surface metal. These are sometimes referred to as gage cracks.

[21] Refer to 49 *CFR* 213.113.

CSXT Petroleum Crude Oil Train Derailment and Hazardous Materials Release

On July 1, 2014, CSXT modified its maintenance-of-way instructions to require a 10 mph speed restriction when a transverse defect is identified—such as the reverse detail fracture found in this accident—until corrective action is taken (such as replacing the rail or applying rail joint bars at the site of the defect).

Pipeline and Hazardous Materials Administration

This accident demonstrates that the thicker shell material used in tank cars designed to the requirements of AAR Casualty Prevention Circular CPC-1232 (non-jacketed option) remain vulnerable to breaches even in low-speed accidents. The Pipeline and Hazardous Materials Safety Administration (PHMSA), in coordination with the FRA, published a final rule May 8, 2015, adopting safety improvements in tank car design standards, operational requirements, and notification requirements for tank cars that are used in trains defined as high-hazard flammable trains (HHFT).[22] The rule also includes new requirements for a sampling and classification program for unrefined petroleum-based products. With respect to tank car and train requirements, the rule specifically provides for:

- Enhanced standards for both new and existing tank cars (for example, full-height head shields and jackets)
- Rail [train] routing (risk assessment and notification)
- Reduced operating speeds
- Enhanced braking

Congressional Action

On December 4, 2015, the president signed the Fixing America's Surface Transportation Act. It calls for real-time emergency response information, a study to determine whether limitations or weaknesses exist in the emergency response information carried by train crews transporting hazardous materials, and additional tank car safety standards. Specifically, tank cars used to transport Class 3 flammable liquids must meet the DOT-117, DOT-117P, or DOT-117R specifications in 49 CFR, Part 179. The new law established a phase-out schedule for certain tank cars not meeting these specifications. It also provides for:

- The US Department of Transportation to issue regulations, as necessary, to require that each tank car built to meet the DOT-117 specifications and each non-jacketed tank car modified to meet the DOT-117R specification be equipped with an insulating blanket
- Minimum requirements for top fittings protection for class DOT-117R tank cars

[22] *Federal Register* 80 No. 78, April 23, 2015.

- Rulemaking on oil spill response plans
- A reporting requirement to monitor industry-wide progress toward modifying tank cars used to transport Class 3 flammable liquids
- Research studies on crude oil characteristics; hazardous materials by rail liability; and study and testing of electronically controlled pneumatic brakes

FRA Rail Failure Working Group Recommendations

The NTSB derailment investigations in New Brighton, Pennsylvania; Columbus, Ohio; and Ellicott City, Maryland, led the FRA to determine that each of the accidents resulted from rail failures. In September 2012, the FRA established a Rail Safety Advisory Committee (RSAC) Rail Failure Working Group to address rail wear issues such as rolling contact fatigue. The working group studied the effects of railhead wear and resulting rail surface conditions (better known as rolling contact fatigue) and how such rail conditions can adversely affect the results of ultrasonic rail testing. The Rail Failure Working Group met four times beginning in January 2013, and completed its task on July 31, 2013.

The group proposed new performance-based recommendations for determining rail wear and internal rail inspection criteria. These criteria ensured the FRA’s ability to effectively monitor rail integrity programs that require track owners to quickly identify and remediate areas that could lead to a derailment. The FRA’s efforts and industry’s acceptance of these best practices should significantly reduce rail accidents caused by broken rails resulting from rolling contact fatigue and improve the industry’s rail risk management programs.

The RSAC adopted the Rail Failure Working Group recommendations on April 16, 2014. The final recommendations developed with industry and other stakeholders formed a consensus document of best practices or guidelines to manage the risks related to rail wear and rolling contact fatigue. Before the guidelines were implemented by CSX, the Lynchburg accident occurred; if they had been implemented, this accident would likely have been prevented.

Previous NTSB Investigations

On October 20, 2006, a Norfolk Southern Railway Company train traveling from Illinois to New Jersey derailed due to a broken rail while crossing a railroad bridge in New Brighton.[23] The NTSB made three safety recommendations (R-08-9, -10, and -11) to the FRA to address ultrasonic rail inspection, rail defect management, and oversee railroad owners’ inspection processes and requirements. The recommendations aimed to address underlying rail conditions caused by rolling contact fatigue. Safety recommendations R-08-9 and R-08-10 are classified as

[23] For more information, see *Derailment of Norfolk Southern Railway Company Train 68QB119 with Release of Hazardous Materials and Fire, New Brighton, Pennsylvania, October 20, 2006*. Railroad/Hazardous Materials Report NTSB/RAR-08/02 (Washington, DC: NTSB 2008).

"Closed—Acceptable Action," and R-08-11 is classified as "Closed—Acceptable Alternate Action."

R-08-9

> Review all railroads' internal rail defect detection procedures and require changes to those procedures as necessary to eliminate exceptions to the requirements for an uninterrupted, continuous search for rail defects.

R-08-10

> Require railroads to develop rail inspection and maintenance programs based on damage-tolerance principles, and approve those programs. Include in the requirements that railroads demonstrate how their programs will identify and remove internal defects before they reach critical size and result in catastrophic rail failures. Each program should take into account, at a minimum, accumulated tonnage, track geometry, rail surface conditions, railhead wear, rail steel specifications and track support, residual stresses in the rail, rail defect growth rates, and temperature differentials.

R-08-11

> Require that railroads use methods that accurately measure railhead wear to ensure that deformation of the head does not affect the accuracy of the measurements.

The NTSB investigated the July 11, 2012, train derailment involving the release of hazardous materials in Columbus. The NTSB determined the probable cause of the accident was a broken rail that exhibited evidence of rolling contact fatigue.

After the Columbus investigation, the NTSB investigated the August 12, 2012, train derailment in Ellicott City. The probable cause was rail failure with evidence of rolling contact fatigue. In these two and the New Brighton accidents, rails with similar wear conditions failed due to detail fractures from shelling, resulting from rolling contact fatigue.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a broken rail caused by a reverse detail fracture with evidence of rolling contact fatigue.

For more details about this accident, visit www.ntsb.gov/investigations/dms.html and search for NTSB accident ID DCA14FR001.

Issued: March 2, 2016

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a railroad accident in which there is a fatality or substantial property damage, or that involves a passenger train. (49 U.S. Code § 1131 - *General authority*)

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties . . . and are not conducted for the purpose of determining the rights or liabilities of any person." 49 *Code of Federal Regulations*, Section 831.4. Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code*, Section 1154(b).