R-640A

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: R-92-23

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Research and Special Programs
Administration
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The National Transportation Safety Board conducted a special investigation on the inspection and testing of railroad tank cars in response to two accidents in which hazardous materials were released because of a structural failure of the tank car.[1] The first accident occurred on January 18, 1992, when three tank cars in a Norfolk Southern Corporation freight train derailed near Dragon, Mississippi. The derailed tank cars (UTLX 89170, CONX 9101, and CHVX 180130) each contained more than 30,000 gallons of liquefied propane, which is regulated as a flammable gas by the U.S. Department of Transportation (DOT). The A-end of CONX 9101 fractured and separated along a circumferential weld where the transition section is joined to the large diameter cylinder of the tank, resulting in the derailment of CONX 9101 and the tank cars coupled to each end of CONX 9101. The separation resulted in the release and ignition of the entire load of propane. Metallurgical examination showed that the discolored area of the fracture surface was extensively oxidized, which is indicative of long-term exposure to a corrosive medium and the presence of a preexisting crack.

CONX 9101, a DOT specification 112J340W dual diameter tank car, operated by Conoco, Inc. (Conoco), was designed and built by General American Transportation Corporation (GATC) and had a load bearing capacity of 125 tons. Postaccident testing and inspection of 108 other DOT class 112 dual diameter tank cars of the same GATC design found that 40 tank cars had cracks in the same location as that on CONX 9101.

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[1] National Transportation Safety Board. 1992. Inspection and testing of railroad tank cars. Special Investigation Report NTSB/SIR-92/05. Washington, DC.

A second accident occurred on March 25, 1992, in Kettle Falls, Washington, and involved a DOT specification 111A100W2 tank car that contained about 13,000 gallons of sulfuric acid. This tank car was built and operated by the Union Tank Car Company (Union). The tank car cracked at the bottom center of the tank along a circumferential weld, resulting in the release of all of the sulfuric acid. There was metallurgical evidence of a preexisting crack in the area of the failure.

In addition to these accidents, cracking and structural failures at stub sill-to-tank car attachments on various classes of DOT specification tank cars have been noted since the mid-1980s. Although these failures in the welds between the stub sill and the attachment pad, or between the attachment pad and the tank, did not result in derailments, the potential for a derailment exists.

The structural failures of the dual diameter tank cars, the nonpressure tank car involved in the Kettle Falls incident, and the stub sills on various types of tank cars all occurred in areas that were subject to high stress and/or cyclical loading. Also, the failures of the CONX 9101 in Dragon, Mississippi, and UTLX 13835 in Kettle Falls, Washington, resulted from preexisting cracks that had gone undetected until the tank failed in transportation. Many of the documented failures of the stub sills also occurred because cracks in various welds between the attachment pads and the stub sill assembly had gone undetected and progagated into the stub sill, resulting in the separation of the stub sill from the tank car.

All of these incidents prompted the Federal Railroad Administration (FRA) and the Association of American Railroads (AAR) to initiate specific testing and inspection programs[2] to determine the extent of the safety problems in tank cars of similar design and construction. Specifically, an extensive stub sill inspection program is underway. Also, the testing and inspection of a representative sample of the fleet of dual diameter tank cars under the FRA's Emergency Order 16 was prompt and responsive to Safety Recommendation R-92-7.[3] The virtual completion of the random testing of the fleet of dual diameter tank cars and the implementation of an ongoing inspection program for dual diameter tank cars found to be susceptible to cracking meet the intent of the recommendation. Therefore, the Safety Board is classifying Safety Recommendation R-92-7 "Closed--Acceptable Action."

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[2] The specific testing and inspection programs initiated by the FRA and the AAR as a result of these incidents are discussed in detail in the Safety Board's special investigation report NTSB/SIR-92/05.

[3] The Safety Board issued Safety Recommendation R-92-7 to the FRA on March 13, 1992. In short, the recommendation urged the FRA to require owners and operators of dual diameter pressure tank cars to inspect a representative sampling of their dual diameter tank cars for evidence of cracks and other serious defects in the circumferential welds between the transition and larger diameter tank shell plates.

However, the stub sill and dual diameter inspection programs implemented by the FRA and the AAR were initiated in response to structural failures that occurred while the tank cars were in transportation, and not as the result of a periodic testing and inspection program.

The Safety Board had previously recognized limitations of in-service testing and inspections during its investigation of an accident at Elkhart, Indiana, in 1985.[4] In its report, the Safety Board concluded that in-service testing and inspection procedures do not provide assurance that head deficiencies will be identified and monitored properly. Therefore, on January 15, 1986, the Safety Board issued a safety recommendation to the FRA to:

R-85-124

Develop a recertification program for tank cars in hazardous materials service fabricated prior to 1967, which will provide assurance that undercut welds in tank car heads are identified and corrected.

In response to this recommendation, the FRA initiated three research projects in 1987 to address (1) cracking in the stub sill area; (2) stress relief and postweld heat treatment of welds in stub sill tank cars; and (3) stress relief of tank cars. The first two research studies have been completed, but the third study is still underway. Also, in a separate response to this recommendation, the FRA issued an Advanced Notice of Proposed Rulemaking (ANPRM) under Docket HM-201 that requested, in part, information about the types of repairs that could lead to cracks and techniques to detect such cracks. Safety Recommendation R-85-124 is classified "Open--Acceptable Response."

Despite actions taken by the FRA in response to Safety Recommendation R-85-124, the Safety Board remains concerned about structural defects that may go undetected and lead to a sudden failure of a tank car during transportation. The Safety Board believes that defects found in the dual diameter tank cars, the nonpressure tank car involved in the Kettle Falls accident, and the stub sills on various types of tank cars must be detected and corrected before they reach a critical size and destroy the structural integrity of the tank car.

Existing DOT requirements for periodic testing and inspection of tank cars depend on hydrostatic tests performed in conjunction with visual inspections to detect structural defects in single-unit tank car tanks. Hydrostatic testing that was initially required as a means of leak-testing the seams of riveted tank cars appears to be an appropriate method to test the integrity of gaskets, seals, and other fittings on welded tank cars.

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[4] National Transportation Safety Board. 1985. Anhydrous hydrogen fluoride release from NATX 9408, train No. BNEL3Y at Conrail's receiving yard, Elkhart, Indiana, on February 4, 1985. Hazardous Materials Accident Report NTSB/HZM-85/03. Washington, DC.

However, the hydrostatic tests conducted on four dual diameter tank cars with known structural defects demonstrates the ineffectiveness of hydrostatic testing as means of assessing the structural integrity of a welded tank. All four dual diameter tank cars successfully passed hydrostatic tests even though they had major cracks in the circumferential weld area between the transition and large diameter sections. Three other dual diameter cars with known cracks, owned by Conoco, passed hydrostatic tests in conjunction with acoustic emissions testing. Also, 40 of 108 dual diameter tank cars of the same design as CONX 9101 were found to have cracks even though 25 of these tank cars had been tested and inspected during or after 1988; 13 of these tank cars were tested and inspected during 1991 and 1992. Although the rate of crack propagation in these tanks was not determined, it is unlikely that cracks in all of these tank cars would have first developed during the relatively recent time period since the last hydrostatic tests were performed. Further, UTLX 18385, which failed because of a preexisting crack in the sump area, was hydrostatically tested only about 1 month before it failed on the first trip following the hydrostatic test. Because hydrostatic pressure tests were successfully performed at higher pressures (300-400 psig) on the dual diameter tank cars with known cracks, the Safety Board does not believe that the hydrostatic test (at a pressure of 100 psig) conducted in February 1992 contributed to the failure of the nonpressure tank, UTLX 18385. Of greater importance, the Safety Board believes that hydrostatic tests are not effective for the detection of structural defects in welded tank cars.

Current DOT regulations also require that a visual inspection of the interior and exterior of the tank car be conducted in conjunction with the hydrostatic test. Visual inspections are useful for the detection of large surface defects that are located on exposed surfaces. Defects on surfaces that are obscured or hidden by corrosion, insulation, an interior tank lining, or a tank jacket will not be detected during a visual inspection. Further, subsurface cracks and defects will not be detected by a visual inspection. CONX 9101, which failed at Dragon, had corrosion on the interior surface of the tank plate and a jacket over the exterior surface of the tank plate. The Safety Board doubts that a visual inspection would have been sufficient to detect the preexisting cracks in CONX 9101 that resulted in its structural failure. UTLX 13835, which failed at Kettle Falls, had a preexisting crack that initiated at the outside diameter and was not detected by the visual inspection performed the month prior to the incident.

Currently, the intervals for testing and inspection of tank cars are based on the type of commodities transported. Tank cars that transport corrosive materials must typically be tested and inspected more frequently than pressure tank cars that transport flammable and compressed gases. General service tank cars that are most commonly used for the transportation of flammable liquids are not required to be periodically tested and inspected until the tank car is 20 years old, and then every 10 years thereafter. Although the type of commodity transported should be a consideration, other factors--such as the likelihood of initiation and the rate of propagation of cracks and other defects in the operating environment--should also be considered.

The DOT regulations also fail to require an effective inspection of the stub sills and other structural members apart from the actual tank. The predeparture inspections that must be performed by traincrews are intended to detect obvious conditions that will prevent a train from arriving safely at its destination. The practices of organizations such as the AAR, the Railway Progress Institute (RPI), and the Chlorine Institute generally supplement the DOT regulations by providing specific procedures for conducting DOT-required tests and inspections, and in certain applications exceed DOT requirements. Although these industry-developed practices provide a definite benefit, the Safety Board does not believe these practices resolve the problems with the detection of structural defects in tank cars transporting hazardous materials.

Consequently, with current DOT regulations and industry-developed standards, major structural defects on a tank car can go undetected until a catastrophic failure occurs. As a result, the FRA, the AAR, and tank car owners and manufacturers are reacting to structural problems after an accident or series of accidents, rather than detecting structural problems through an effective testing and inspection program.

The Safety Board recognizes and commends the prompt action of the FRA, the AAR, and the tank car owners and manufacturers in responding to the problems with the dual diameter tank cars, and the failure of UTLX 13835. The Safety Board is also aware of the continuing efforts of the FRA and the AAR to resolve the problems with stub sill separations.

However, the Safety Board believes that an effective program of periodic testing and inspection must be implemented to detect major structural defects before they have the potential of causing catastrophic failures. The structural failures described in the Board's special investigation report all resulted from the development of fatigue cracks that propagated, undetected, to critical length.

The Safety Board believes that a damage-tolerance approach to periodic testing and inspection of railroad tank cars would substantially increase the likelihood of detection of cracks and other defects before they result in catastrophic failure. The elements of a damage-tolerance approach should (1) identify areas and components on tank cars that are prone to failure from high stress and fatigue, and (2) determine inspection intervals that are based on the defect size detectable by the inspection method used, the stress level, and the crack propagation characteristics of the structural component.

The Safety Board recognizes that the current nondestructive testing (NDT) techniques such as acoustic emissions, ultrasound, radiography, dye penetrants, and magnetic particle testing have differing capabilities and limitations. Although the AAR's Tank Car Committee is investigating the use of acoustic emissions testing on tank cars, difficulties encountered with the acoustic emissions testing of three dual diameter tank cars owned by Conoco demonstrate that acoustic emissions testing of rail tank cars needs further refinement to be a viable inspection method in this application. The Safety Board also believes that certain NDT techniques may be more appropriate than others for different structures on the tank car. Also, it

may be necessary to utilize two or more inspection techniques to properly inspect certain configurations of tank cars, such as those with jackets or thermal insulation. The capabilities of the inspection methods used are the major determinant of the inspection intervals in the damage-tolerance approach to continued safe operation of the tank cars. The Safety Board, therefore, is urging the FRA, the AAR, the RPI, and the Chlorine Institute to evaluate NDT techniques and to determine how such techniques can be applied for periodic testing and inspection of all tank cars that transport hazardous materials.

The Safety Board also believes that standards for periodic testing and inspection, based on a damage-tolerance methodology, should be implemented under Docket HM-201 for rail tank cars. Further, the Safety Board believes that every effort should be made to expedite the rulemaking under Docket HM-201. Consequently, the Safety Board urges the FRA and the RSPA to develop and promulgate requirements for the periodic testing and inspection of rail tank cars that help to ensure the detection of cracks and other defects before they can grow to critical length and cause catastrophic failure of the tank car.

Therefore, as a result of its special investigation, the National Transportation Safety Board recommends that the Research and Special Programs Administration:

> Develop and promulgate, with the Federal Railroad Administration, requirements for the periodic testing and inspection of rail tank cars that help to ensure the detection of cracks before they propagate to critical length by establishing inspection intervals that are based on the defect size detectable by the inspection method used, the stress level, and the crack propagation characteristics of the structural component (requirements based on a damage-tolerance approach). (Class II, Priority Action) (R-92-23)

Also as a result of its special investigation, the Safety Board issued recommendations to the Federal Railroad Administration, the Association of American Railroads, the Railway Progress Institute, and the Chlorine Institute.

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HART, and HAMMERSCHMIDT concurred in this recommendation.

By: Carl W. Vogt
Chairman