



National Transportation Safety Board

Washington, D.C. 20594

Hazardous Materials Accident Brief

Accident No.:	DCA-96-MZ-002
Transportation Mode:	Rail
Type of Accident:	Tank car failure and release of flammable and toxic liquid
Location:	Sweetwater, Tennessee
Date and Time:	February 7, 1996; 5:30 a.m.
Carrier:	Norfolk Southern Railway Company
Shipper:	Akzo Nobel Chemical Company, Inc.
Tank Car Specification:	DOT 111A100W1
Tank Car Manufacturer:	General American Transportation Corporation
Injured:	4 people treated and released; 1 person admitted
Evacuated:	Approximately 500 people
Material Released:	Carbon disulfide, flammable liquid (toxic)
Type of Failure:	Circumferential fracture

The Accident

About 5:00 a.m. eastern standard time on February 7, 1996, in Sweetwater, Tennessee, Norfolk Southern eastbound train M34T5 stopped on the main track to allow a westbound train to pull onto a siding. About 5:30 a.m., as the engineer began to move his train forward, an uncommanded emergency brake application occurred. The train had moved about 33 feet and reached a speed of about two mph.¹ When the train conductor walked back to determine the cause of the emergency brake application, he discovered that tank car GATX 92414 had separated almost completely into two halves near the middle of the tank and that about 8,000 gallons of carbon disulfide, a flammable and toxic material, had spilled.² As a result of the spill, about 500 people were evacuated from the area, including residents of a nursing home. Five people were seen at a local hospital, but only one person was admitted.

About noon on February 9, 1996, emergency crews determined that the released carbon disulfide did not pose a problem outside the immediate area of the tank car, and the evacuation order was lifted. The Sweetwater Fire Department then relinquished control of the site to the Environmental Protection Agency on-scene coordinator (EPA OSC), and the focus of the activities at the site became environmental cleanup and product recovery.

¹Postaccident testing indicated that, when the failure occurred, GATX 92414 was subjected to a maximum drawbar force of about 160,000 pounds, which is considered to be within the normal operating range.

²The tank failure had broken the train's air brake line, resulting in the emergency brake application.

About 4:45 p.m. on February 9, the EPA OSC decided to permit access to the tank car to examine the fracture surfaces before the tank was moved. Initially, polyethylene tarpaulins and plywood were placed over the spill area near the failed tank car. However, at 10:00 p.m., after discussions with the chemical shipper, Akzo Nobel Chemicals, Inc., the EPA OSC became concerned that the polyethylene tarpaulin and plywood could trap pockets of carbon disulfide vapors, which could possibly be ignited by people walking over the tarpaulin.

At 1:40 a.m. on February 10, as Norfolk Southern contractor personnel were attempting to remove the tarpaulin, a flash fire occurred. Four contractor personnel were caught in the flash fire, but because the fire was of short duration and the flames were low to the ground, no injuries resulted. Sweetwater emergency response agencies were not on scene at the time, but the Sweetwater fire chief resumed control of the site shortly after this fire and initiated a second area-wide evacuation. On February 12, following cleanup activities at the site, this evacuation was lifted.

The Tank Car

Tank car GATX 92414 was built in 1969 by the General American Transportation Corporation (GATC) as a Department of Transportation (DOT) specification 111A100W1 stub-sill tank car.³ The tank was constructed of ASTM A-515-70 steel with a minimum thickness of 7/16 inch. A 1986 Federal Railroad Administration (FRA) task force report⁴ noted that this steel has a ductile-to-brittle transition temperature of 30 °F.⁵ The ambient temperature at the time of the accident was about 24 °F, and the temperatures in the region the night before had been even lower.

On July 1, 1974, the Association of American Railroads (AAR) revised freight car design requirements because of increased train loads and evidence that the tanks of some stub-sill tank cars, primarily those built by GATC, were prone to buckling near the stub sills. In 1975, the AAR established voluntary provisions that would permit existing tank cars to be modified and approved as meeting the new standards. By July 1990, after determining that tank buckling was still occurring on unmodified cars, the AAR required that all such tank cars be modified in order to remain in normal rail service.

In response to the new standards, GATC initiated a long-term program to modify its stub-sill tank cars through the addition of reinforcement bars. In 1990, tank car GATX 92414 was sent to the GATC tank car shop at Hearne, Texas, to have reinforcement bars welded to the bottom of the tank. The modification design called for two continuous outer reinforcement bars extending along the entire length of the tank and one discontinuous center bar extending from either end of the car to almost the middle of the tank. (See figure 1A.) The two outer bars were designed to

³*Stub-sill* tank cars are those that do not have a continuous center sill that extends the length of the tank and that serves as a support for the tank. These cars have a stub sill assembly welded to each end of the tank, with the tank itself serving as the car's primary structural member.

⁴P. Tong, F. Erdogan, R. Fields, F.A. McClintock, O. Oringer, R.M. Pelloux, A.B. Perlman, and G.C.M. Sih, *DOT-105/111/112/114 Tank Cars Shell Cracking and Structural Integrity Assessment*, November 1986, DOT Transportation System Center, Cambridge, Massachusetts, Task Force Report.

⁵Beginning in 1987, the Association of American Railroads prohibited the use of ASTM A-515-70 steel in new tank car construction. Tank cars manufactured since 1987 must be constructed of fine-grain steel (ASTM A-516-70), which has enhanced material properties.

carry most of the live-load stresses⁶ on the car. According to the design, metal “pads” were to be welded⁷ to the bottom of the tank, and the reinforcement bars were to be filet welded, along their entire length, to these metal pads.

Postaccident examination of GATX 92414 revealed that neither of the two outer reinforcement bars extended the length of the tank. (See figure 1B.) Instead, all three bars were discontinuous, stopping in the middle of the tank within inches of the center sump plate, and each bar had welds near its termination point. Because records for the modification of GATX 92414 were discarded after 5 years, as allowed by Federal regulation, no records exist to explain why the reinforcement bars were not attached according to the modification design.

According to GATC, in response to changes in the AAR’s quality assurance requirements, the company in 1993 established a written quality assurance program, enhanced its training programs, and developed more detailed work cards that identify procedures used for tank car modifications. The company said that both shop and quality control personnel are now responsible for ensuring that tank car repairs are performed in accordance with the GATC requirements, specifications, and engineering designs.

Tank Car Failure -- Postaccident examination of the fracture surface revealed that the majority of the surface contained chevron markings typical of an overstress fracture that pointed to a fracture origin area at the lower center portion of the tank shell in the area of two small preexisting cracks. The largest crack measured approximately 0.41 inch long at the tank surface and was about 0.18 inch deep. The other crack measured approximately 0.27 inch long at the outer surface and was about 0.1 inch deep. These cracks were at or near the tips of two filet welds on the end of the pad for one of the reinforcement bars near the center of the tank. (See Figure 1B.) A small band area in the cracked region adjacent to the overstress fracture had features indicative of fatigue propagation; however, most of the surface of the two cracks was covered with black oxide deposits of the type typically formed when steel is subjected to extreme heat, such as the heat of welding. The fracture surface outside the crack regions was mostly cleavage indicative of a brittle fracture.

⁶The term “live-load stresses” refers to the forces on the tank shell associated with the tank car and cargo weight and the in-train forces.

⁷Using “intermittent” filet welds, with no single bead longer than 3 inches.

FRA Study of Bottom Reinforcement Bars

A 1987 FRA task force report entitled *DOT-111A/100W Tank Cars Special Retrofit Stiffener Integrity Assessment*⁸ concluded that a discontinuous stiffener, or a bottom reinforcement bar, in conjunction with a weld end,

would decrease the safe crack growth life and safe inspection period by a factor of 8.... Another way to view this result is to note that, for [inspection] intervals of practical use, the stiffener discontinuity creates a stress concentration sufficient to allow undetectable cracks to grow to failure under normal service conditions.

The report also stated that a discontinuous stiffener that ends in the middle third of the tank increases the stress in the middle of the tank and poses an unacceptable risk to the shell integrity.

Postaccident Actions

Tank Car Inspections -- After the accident, GATC identified 97 tank cars still in rail service that were similar in design and construction to GATX 92414. The AAR issued several mechanical advisories,⁹ and by September 1996, all 97 tank cars had been stopped and inspected; 14 of the cars had discontinuous bars, and 9 cars were found with cracks at the reinforcement bar welds.¹⁰ By December 1997, all tank cars containing discontinuous reinforcement bars and weld cracks had been scrapped.

To determine the extent to which the problem affected other modified GATC tank cars, the FRA, the AAR, and GATC performed a 2-week focused inspection of tank cars built by GATC before 1974 and later modified. From a total of 6,000 such cars, 739 were randomly selected and inspected to determine whether other modifications had occurred which resulted in the installation of discontinuous reinforcement bars when the modification design called for continuous bars. No such modifications were found.

In June 1997, GATC developed fleet maintenance instructions directing that the 18,427 tank cars the company built between 1969 and 1982 be inspected at the time of their next shopping for any reason. Cars fitted with reinforcement bars are to be inspected for cracks at bar terminations, welds, and pads, and any cracks found are to be repaired. This program goes beyond 49 CFR 180.509(e), which requires that this inspection be performed during prescribed periodic inspections.

Emergency Response -- According to the EPA, all of its on-scene coordinators are now being trained to include local emergency response agencies, such as the Sweetwater Fire Department, in all decisions and actions taken at a spill site. The U. S. National Response Team,

⁸P. Tong, F. Erdogan, R. Fields, G.E. Hicho, F.A. McClintock, O. Oringer, R.M. Pelloux, A.B. Perlman, and G.C.M.Sih, *DOT-111A/100W Tank Cars Special Retrofit Stiffener Integrity Assessment*, April 1987, DOT Transportation System Center, Cambridge, Massachusetts, Task Force Report.

⁹A *mechanic advisory* is a notification to the AAR members that allows a carrier to refuse to accept in interchange a specifically designated category or group of rail cars owing to serious concerns that relate to the safety of operations.

¹⁰Three of the tank cars had both discontinuous bars and cracks at the welds.

of which EPA is a primary member, issued, in June 1996, a technical assistance document titled "Incident Command System/Unified Command" to help accomplish such coordination.

Sweetwater emergency response agencies have taken several initiatives following this accident to enhance their overall response capability, including providing training in incident command and control organizational procedures, funding a new police/fire central communication facility, developing a list of available hazardous materials specialists, and developing a city mass casualty plan.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the failure of tank car GATX 92414 was the installation of discontinuous bottom reinforcement bars, which concentrated stresses on preexisting welding-induced cracks in the middle of the tank. Contributing to the severity of the failure was the brittleness of the tank steel, which promoted the rapid propagation of the overstress fracture and led to an almost complete separation of the tank.

Adopted: April 20, 1998