National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 1, 2004

In reply refer to: H-04-23

Mr. Samuel G. Bonasso
Acting Administrator
Research and Special Programs Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 11:50 a.m. central daylight time on April 15, 2003, a nonspecification cargo tank used by River Valley Cooperative (River Valley) exclusively for agricultural purposes as a nurse tank split open after being filled with anhydrous ammonia at River Valley's nurse tank filling facility near Calamus, Iowa. About 1,300 gallons of the poisonous and corrosive gas escaped, seriously injuring two nurse tank loaders, one of whom died from his injuries 9 days after the accident. The National Transportation Safety Board determined that the probable cause of the accident was inadequate welding and insufficient radiographic inspection during the tank's manufacture and lack of periodic testing during its service life.[1]

A postaccident metallurgical examination indicated that a portion of the nurse tank's interior longitudinal weld was not centered on the shell seam. Further, in one area where the inner weld was offset to one side of the shell seam, there was a region of incomplete fusion that was 3.25 inches long and up to 0.102 inch deep. Based on the metallurgical findings, the Safety Board concluded that a crack had initiated from the unfused area of the longitudinal weld in the nurse tank, most likely during the manufacturing proof pressure test, and had grown through the tank shell by fatigue until the tank shell failed under normal operating conditions. Consequently, the Safety Board identified the adequacy of standards for initial qualification and periodic testing of nurse tanks as a safety issue.

The U.S. Department of Transportation (DOT) requires that the nonspecification cargo tanks known as nurse tanks be manufactured in accordance with the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code*. However, as long as nurse tanks meet the general criteria set forth in section 173.315(m) of the Hazardous Materials Regulations, they are not required to meet any additional DOT-specified requirements.

The accident nurse tank manufacturer, Trinity Industries, Inc., (Trinity) stated that the accident nurse tank was manufactured in 1976, in adherence with the standards in the ASME *Boiler and Pressure Vessel Code*, Section VIII. As permitted by the code, Trinity used spot

[1] For additional information, see National Transportation Safety Board, *Nurse Tank Failure With Release of Hazardous Materials Near Calamus, Iowa, on April 15, 2003*, Hazardous Materials Accident Report NTSB/HZB-04/01 (Washington, DC: NTSB, 2004).

radiography to qualify the longitudinal welds on its nurse tanks. The use of spot radiography meant that only one representative 6-inch-long radiograph was used to ensure the quality of every 50 feet of Trinity's nurse tanks' longitudinal welds. In other words, this method tested only 1 percent of the length of the longitudinal welds on Trinity's nurse tanks. Further, because the code does not specify that a spot radiograph must be taken from each nurse tank and because Trinity's tank shell lengths range from 12 to 15 feet, a single 6-inch-long radiograph could have been used to qualify the longitudinal welds on three or four nurse tanks. Consequently, most of the tanks produced by Trinity during this period received no individual radiographic testing of their welds.

Use of the spot radiography method to qualify the longitudinal welds on nurse tanks allows the majority of these welds to go uninspected and significantly reduces the likelihood that critical defects and flaws that would result in the rejection of the welds will be detected. Had a full radiographic examination been made on the accident nurse tank during its manufacture, the 3.25-inch-long weld flaw it contained likely would have been detected and the tank repaired or rejected. The Safety Board concluded that using spot radiography to qualify longitudinal welds in nurse tanks manufactured to transport anhydrous ammonia, a poisonous and corrosive gas, is not a sufficiently reliable method of detecting critical flaws that can result in tank failure.

Since the mid-1980s, as the result of the development of radioscopy, a radiographic technology that allows real-time examination of the longitudinal weld, the two manufacturers of nurse tanks currently comprising the industry have chosen to examine the full lengths of the longitudinal welds on all their nurse tanks using radioscopy. Thus, this full radiography method of qualifying longitudinal welds has become general practice in the nurse tank manufacturing industry. However, under existing regulations, the manufacturers of nurse tanks can, if they choose, return to using spot radiography to verify longitudinal tank welds. Although it does not appear likely that nurse tank manufacturers will return to using spot radiography to qualify longitudinal welds, if they chose to do so it would increase the risk that they would fail to identify weld defects during the manufacturing qualification process. Given the serious consequences of a major anhydrous ammonia release, which could be caused by a weld defect, the Safety Board urges the Research and Special Programs Administration to monitor nurse tank manufacturers to ensure that they continue to use a full radiography method of qualifying the longitudinal welds of their nurse tanks.

After being manufactured and proof pressure-tested, the accident nurse tank was never required to undergo periodic testing of any kind to ensure its safety during its service life. The Safety Board determined that the initial crack in the nurse tank shell was likely introduced during the nurse tank's original proof pressure test in the manufacturing process in 1976.[2] Because the crack was not visible on the outside surface of the tank, exterior examination during or after manufacture would not have detected the crack. Because the nurse tank had no openings larger than about 2 inches in diameter and internal baffles blocked portions of the interior shell from visual examination through those openings, attempts at normal internal visual inspection would also have been unsuccessful. However, given the crack's considerable size and the fact that it penetrated 83 percent of the tank shell thickness, it could have been detected during the service

[2] Because the ASME requires proof pressure testing to be performed after all manufacturing and testing has been completed, the crack did not exist when the initial manufacture spot radiography qualification of the accident nurse tank's welds took place.

life of the tank by a variety of nondestructive testing methods. The Safety Board concluded that periodic nondestructive testing could have detected the weld defect and internal crack in the nurse tank during its service life, and the tank could have been repaired or removed from service before it failed.

Neither the DOT, the Occupational Safety and Health Administration, nor ASME has requirements for periodic inspection and testing of nurse tanks. Although the DOT Hazardous Materials Regulations establish periodic testing requirements for specification cargo tanks and all other specification bulk containers used to transport hazardous materials (including anhydrous ammonia), nurse tanks are excepted from these requirements. In fact, with the single exception of nurse tanks, all nonspecification cargo tanks built to the same configuration as nurse tanks are required to have periodic inspection and testing.

Of bulk containers that are used to transport hazardous materials, only nurse tanks are allowed to transport anhydrous ammonia without being required by the DOT to undergo some type of periodic inspection and/or testing during their service lives to ensure tank integrity. Nurse tanks, like any other cargo tank in pressurized service, experience stress and wear as they undergo repeated pressure cycles over months and years of service. They also are often transported over back roads, where pavement surfaces may be rough, as well as into fields. Such transport environments could put additional stress on the tanks. Some deterioration of nurse tank condition after years of service under these conditions seems inevitable.

According to The Fertilizer Institute, an estimated 200,000 nurse tanks are in service today. These apply between 1.0 million and 1.5 million loads of anhydrous ammonia to fields annually. The institute also estimates that only one to five nurse tanks are removed from service each year. Because they are not required to be removed from service at a given age, many nurse tanks that have received no effective safety inspections for several decades likely remain in use on farms and at filling facilities. In addition, based on the practices used by Trinity and other nurse tank manufacturers, it appears that many of the tanks that were manufactured before the mid-1980s did not receive full radiographic examination of their longitudinal welds upon manufacture. As shown by this accident, an undetected flaw in a longitudinal weld can cause a serious accident many years after a nurse tank's manufacture.

Further, the information provided by the Minnesota Department of Agriculture through its unique 1996 program during which between 1,500 and 2,000 nurse tanks underwent nondestructive testing to enable the tanks to be certified indicates that some nurse tanks in use may have corrosion, denting, or leaking problems requiring repair. Unless they are detected by an inspection and testing program, however, these defects might go unnoticed and continue to grow until a tank failure and anhydrous ammonia release occurs. The Minnesota program information also indicates that some of the defects found in the State's nurse tanks in the course of the 1996 program were so extensive the tanks could not be successfully repaired. At least 10 of the tanks tested eventually had to be removed from service because they could not be made sufficiently sound. Had Minnesota not detected these defective tanks through its own program, these tanks—containing serious defects—might still be in service today. Nurse tanks in other States may have integrity problems similar to those discovered in the Minnesota program.

In addition, Minnesota State officials told investigators that in 1995 two nurse tanks in the State had had catastrophic failures. The two tanks had been manufactured by Trinity in 1973 and likely were produced in the same manufacturing lot. Both tanks split open at the middle circumferential weld, one in a storage yard and one as it was being transported on the road. Although no failure analysis was performed on these tanks, the State considered that a manufacturing defect and/or a design problem may have been factors in their failures.

Although failures of nurse tanks may be rare, when they occur, as in the case of the Calamus accident, they can be catastrophic, given the extremely hazardous nature of the anhydrous ammonia they contain.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Research and Special Programs Administration:

> Require periodic nondestructive testing to be conducted on nurse tanks to identify material flaws that could develop and grow during a tank's service and result in a tank failure. (H-04-23)

The Safety Board also issued a safety recommendation to the River Valley Cooperative.

Please refer to Safety Recommendation H-04-23 in your reply. If you need additional information, you may call (202) 314-6177.

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members CARMODY, HEALING, and HERSMAN concurred in this recommendation.

Original Signed

By: Ellen Engleman Conners
Chairman