National Transportation Safety Board

Washington, D. C. 20594

Safety Recommendation Log H-579

Date: July 7, 1988

In reply refer to: H-88-26 and -27

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Administrator
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Washington, D.C. 20590

On January 4, 1988, an MC 307 tank trailer operated by DSI Transport, Inc. (DSI), departed the Air Products, Inc., terminal in St. Gabriel, Louisiana, with 39,000 pounds of mono-isopropylamine, a flammable liquid. The truck was en route to the Pennwalt Corporation's plant in Wyandotte, Michigan. The truckdriver reported that about 5:30 p.m. on January 5, as the truck was proceeding northbound on Interstate 65 about 3 miles north of Sonora, Kentucky, he heard a loud noise similar to a blowout and the truck jerked hard to his left. In the sideview mirror, the truckdriver saw sparks coming from the rear of the vehicle. Although difficult, the truckdriver moved the vehicle onto the shoulder of the road and stopped. He disembarked and extinguished a fire beneath the trailer which he believed was being fueled by grease on the support pads of the trailer's dolly legs.

The truckdriver said that the tank had collapsed inward between the fourth and fifth stiffening rings causing the tank bottom to sag such that the dolly legs and spare tire rack were dragging on the roadway and creating severe folds in the top and upper sides of the tank shell. Although none of the tank's contents was released, the catastrophic failure of the tank severely impaired the driver's ability to control the vehicle, creating the potential for a serious highway accident which would have resulted in the release of the hazardous cargo. Following the accident, the tank was off-loaded, cleaned, and transported to Deer Park, Texas, for inspection and repair.

The loading temperature of the cargo was reported to be between 70° F and 80° F. When the tank collapsed, the ambient air temperature was approximately 10° F. With a large decrease in temperature, such as experienced in this incident, the volume of a liquid material can be significantly reduced. Calculations by the shipper estimated that the mono-isopropylamine contracted from an initial volume of 6,905 gallons to a final volume of 6,540 gallons, a volume reduction of 5.3 percent. (For comparison, anhydrous hydrogen fluoride, a material with an extremely high coefficient of thermal expansion, would contract approximately 9 percent over a comparable decrease in temperature, whereas gasoline would contract approximately 3.5 percent.) The internal pressure within the vapor space in the tank would have decreased from 19.7 to 10.8 pounds per square inch, absolute (psia), to produce a vacuum of 4.1 pounds per square inch (psi). The shipper assumed in these calculations that no air was introduced into the tank vapor space as the liquid contracted.

The tank, built by Butler Transportation Equipment Corporation in 1979, was 41 feet long and 68.5 inches in diameter. It was constructed of stainless steel, designed for a pressure of 30 pounds per square inch, gauge (psig), and had a nominal capacity of 7,500 gallons (58,000). The tank did not have a vacuum design rating. The tank was equipped with a single-flanged pressure relief valve, which was manufactured by Girard Equipment, Inc., and was rated at 32 psig. The valve was equipped with a nonrated vacuum arrester that consisted of a steel ball and spring housed in Teflon.

In December 1987, DSI conducted the Department of Transportation (DOT) required biennial inspection and its own 60-day required inspection. The DOT inspection is always performed in conjunction with one of DSI's 60-day inspections. To comply with the DOT requirements, DSI inspected the external areas of the tank for evidence of corrosion; defects in welds, piping, valves, and gaskets; and signs of leakage. Additionally, the pressure relief valve was bench-tested because it was rated in excess of 7 psig. The DSI-required, 60-day inspection exceeds DOT requirements by including routine inspection of the tank interior, sonic tests to measure shell thickness, and cleaning or replacing all components of the pressure relief valve. New internal components for the pressure relief valve were installed in December 1987.

Between the December 1987 inspection and the January 5 incident, the tank had transported five shipments: two were mono-isopropylamine, one was mono-isopropanolamine, one was alcohol not otherwise specified (n.o.s.), and one was a combustible liquid n.o.s. identified as n-methyl pyrrolodine.

Sonic measurements of the shell taken at the DSI terminal in Deer Park on January 13, 1988, in the presence of a Safety Board investigator were consistent with the sonic measurements taken during the DSI inspection in December 1987. The sonic measurements indicated that the tank shell thickness complied with the DOT design specifications. The interior tank did not show evidence of pitting or other signs of corrosion. The failure area was not centralized along a weld.

The pressure relief valve also was removed and inspected. The internal components looked clean and new. During a bench-test of the valve, the pressure relief device opened at 27 to 28 psig (41.7 to 42.7 psia). The operation of the vacuum arrester was not consistent. It opened at vacuum pressures ranging from 1 to 11 psia. Upon completion of the bench-test, the Teflon housing of the vacuum component felt tacky and the steel ball appeared to be sticking slightly to the housing.

The Safety Board was not able to determine whether the vacuum arrester on the pressure relief valve had malfunctioned, had the capacity to relieve the vacuum formed due to the drop in temperature experienced during transportation, was affected by previous cargo residue, or did not perform due to some other factor. The vacuum arrester was not required to be installed on the MC 307 tank. Also, the manufacturer's brochure cautions that the vacuum arrester, due to its limited size, should not be relied upon wholly to prohibit the implosion of a tank vehicle.

Current MC 307 design specifications in 49 Code of Federal Regulations (CFR) 178.342-4 do not establish vacuum design criteria or require the use of vacuum relief devices to prevent the development of a critical vacuum. The regulations do, however, require protection against overpressuring a tank and specify performance criteria for devices used to achieve this protection.

Under dockets HM-183 and HM-183A, the Research and Special Programs Administration (RSPA) published a Notice of Proposed Rulemaking at FR 37766 on September 17, 1985, which proposes to revise the MC 306, MC 307, and MC 312 tank design specifications. Proposed paragraph 178.340-10 would require that all MC 306, MC 307, and MC 312 tanks be equipped with a pressure and vacuum relief system of sufficient capacity to prevent tank rupture or collapse under any condition of overpressurization or vacuum resulting from tank heating, cooling, loading, or unloading. The paragraph specifies performance criteria which must be met by the pressure relief devices. However, other than the general requirement for vacuum relief protection, no performance criteria or other standards for vacuum relief devices on these tanks have been proposed.

Both the existing regulations and those proposed under HM-183 and HM-183A include explicit standards for pressure relief devices and tank design pressures as measures to safeguard against overpressurization. However, neither the existing regulations nor those proposed under HM-183 and HM-183A include explicit standards for vacuum relief devices and tank design pressures as measures to safeguard against tank collapse due to a vacuum.

In this incident, a cargo tank that met DOT specifications failed under normal conditions of transportation. The failure was sudden, occurred without warning, and severely impaired the driver's ability to control the vehicle. The tank collapsed due to the development of an excessive vacuum within the tank. Factors contributing to the vacuum failure were the large reduction of temperature encountered during transportation, the moderately high coefficient of thermal expansion of the mono-isopropylamine, the failure or inability of the vacuum arrester to prevent formation of a vacuum, and the failure of the DOT to establish vacuum protection design and performance criteria in 49 CFR 178.342 for MC 307 cargo tanks.

Tanks and containers for hazardous materials, as a minimum, should retain their integrity under conditions normally incident to transportation. Containers offered into transportation should neither release hazardous materials under normal conditions nor suffer catastrophic failures under normal conditions.

Currently, the RSPA does not require carriers to report incidents of cargo tank collapse which involve release of hazardous materials unless other loss criteria are met. According to 49 CFR 171.16, a carrier must submit a Hazardous Materials Incident Report (HMIR) in the event of death, injury requiring hospitalization, property damage exceeding $50,000, or unintentional release of the hazardous material. A carrier also may submit an HMIR if, in the carrier's judgment, the incident should be reported. DSI has indicated that it does not intend to submit to RSPA an HMIR regarding the January 5 tank failure because there was no release of cargo. Because of the reporting deficiency, it is not possible to determine the frequency of or the potential hazards posed to public safety by vacuum failures of cargo tanks. However, based on a 1984 report prepared by Dynamic Science, Inc., for the DOT, 1/ it is evident that the January 5 tank failure is not unique and that the cargo tank transportation industry is concerned about such failures. The 1984 report stated that one carrier, cited as having experienced an average of one vacuum collapse

1/ "Integrity of MC 307/312 Cargo Tanks."

per year, recommended that vacuum venting be improved for MC 307 tanks. If incidents in which containers fail without releasing cargo are not reported, the performance history of the container transporting hazardous materials may appear to be good, when in fact, a fundamental problem may exist.

Title 49 CFR 394.3 requires motor carriers to submit to the Federal Highway Administration (FHWA) an accident report in the event of an occurrence resulting in death, bodily injury resulting in medical treatment, or property damage of $4,400 or more. The January 5 incident appears to be a reportable occurrence since damage to the tank trailer likely will exceed the $4,400 limit; however, similar, less-severe incidents probably would not have been reported. Even though some vacuum failures may be reported to the FHWA under the motor carrier reporting system, this data system is not linked to, or accessible from, the Hazardous Materials Information System database. Further, the types of data collected under the motor carrier database are not useful for assessing the performance of cargo tanks.

Therefore, the National Transportation Safety Board recommends that the Research and Special Programs Administration:

> Establish quantitative criteria for determining when Department of Transportation specification cargo tanks must be protected against vacuum failure. The criteria should prescribe explicit standards for design, operation, and maintenance of vacuum relief devices when required. (Class III, Longer-Term Action) (H-88-26)
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> Revise the criteria for reporting hazardous materials incidents to include vacuum failures of cargo tanks. (Class III, Longer-Term Action) (H-88-27)

Also, the Safety Board issued Safety Recommendation H-88-28 to the Federal Highway Administration.

BURNETT, Chairman, KOLSTAD, Vice Chairman, and LAUBER and NALL, Members, concurred in these recommendations. DICKINSON, Member, did not participate.

By: Jim Burnett
Chairman