Rupture of an Ammonia Road Tanker

If accidents like the one described here are to be prevented, particular attention must be paid to the methods for installing interior baffles and external stiffening beams on road tankers.

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At about midday on Wednesday, August 21, 1968 the tank of a semi-trailer truck filled with ammonia suddenly ruptured in the yard of a factory at Lievin (Pas de Calais), France. The almost instantaneous escape of ammonia which resulted caused burns to the respiratory organs of 20 persons, five of whom died. As will be seen, this disaster must be considered more as a transport accident than as an accident related to plant operation.

Circumstances of the accident

A Belgian nitrogen producer hired a transport company to carry 19 tons of ammonia from a factory in Belgium to the Lievin factory of Societe Chimique de la Grande Paroisse (SCGP). The tank, which had been filled between 4 a.m. and 6 a.m., arrived at Lievin shortly before 11 o'clock in the morning.

The tank was weighed and, at about noon, taken to one of the unloading bays. The driver returned to the cab of his vehicle while a SCGP worker connected the hoses linking to the factory's stock tanks. The gas pressure in the tanker and the factory stock tank was equalized, but the transfer compressor was not started. At this time the pressure in the system was approximately 175 psig.

At around 12:20 p.m., an employee arrived from the plant to take a sample. When he was about 30 meters from the tanker, he heard a loud noise and saw a white mushroom shaped cloud formed by the escaping ammonia. He hurried to a neighboring building and informed his fellow workers who escaped by a distant exit.

Six workers who were eating their meal in a building situated about 25 meters from the tanker were alarmed by the noise and went to investigate. Upon arriving in the yard they were enveloped in a cloud of ammonia gas. Three of them collapsed and died. Four other workers who were eating lunch in another building were able to escape by climbing over the nearby perimeter wall.

Examination showed that the tanker had ruptured along a straight line around the circumference into two unequal parts. The rear section, which was about 3 meters long and contained the service parts, recoiled only a few meters before imbeding itself into the ground because it was joined by articulated metal arms to the transfer system. The other part, about 8 meters long and resting partly on the four wheeled trailer, and partly on the saddle of the truck, was propelled through the brick wall of a nearby building. The truck moved forward a few additional meters before being crushed against a heavy obstruction. The unfortunate driver, still in the cab of his vehicle, was killed instantly.

Vaporization of the spilt ammonia was speeded up when it mixed with a flood of water pouring from a large water pipe ruptured by the truck. The cloud of ammonia, blown by breeze, soon reached the neighboring streets forcing residents to flee their homes.

The tank was built in 1964 at Velsen in the Netherlands under the control of Apragaz, a Belgian organization, which had, in advance, approved calculations and designs prepared by the tank fabricator. The tank, constructed of Tl steel, consisted of four strakes with two dished ends and three interior baffles.

Construction material characteristics

Tl steel, produced by U.S. Steel Corp., is a low nickel-chrome-molybdenum alloy which also contains 0.15% to 0.50% copper. Its nominal mechanical proper thicknesses of not more than 60 mm. are:

Yield point More than 70 hectobars (45 tons/sq.in.)
Tensile strength – From 80 to 93 hectobars (52 to 61 tons/sq.in.)
Percentage elongation – More than 18%
Impact test – (Charpy V) at −12°C
Transverse – 30 ft./lbs.

At the time it was constructed the tank was intended to carry propane. It had been tested hydraulically at a pressure of 430 psig. The checks on characteristics (stretching, bending, and toughness) of the metal, as well as tests carried out by radiographic control of all welds, were deemed satisfactory by Apragaz, which had an employee supervising its construction in the workshop. The values found by Apragaz were as follows:

Yield point – 80 to 83 hectobars (52 to 54 tons/sq.in.)
Tensile strength – 84 to 87 hectobars (54.8 to 56.7 tons/sq.in.)

These figures show the metal to have characteristics superior to those offered by its supplier. The certificate, issued in February 1964 by Apragaz, concluded that the tank could be safely used for transporting liquefied propane and butane, on the condition that an internal and external examination and a hydraulic test be carried out every ten years. The tank was not heat treated after fabrication. It was sent to the workshops at Mol, Belgium to have wheel bogies, coupling attachments, electrical apparatus, and other equipment installed. It left the workshops in March 1964 as a road tanker.

Towards the end of 1967, the owner requested Technicontrole, another Belgian firm, to examine the semi-trailer tanker to see if it could carry ammonia. After a visual examination of the interior and exterior of the tank, and taking into consideration the calculations of the fabricator, Technicontrole stated in November 1967 that the tank was suitable for ammonia transport, and fixed the maximum load at 20 tons.

We think it important to point out that the rear of the tank (the fourth strake) was entirely overhung. The baffles were fixed by bolts to a fabricated tee which was welded to the shell in the neighborhood of the welds between strakes. There was, therefore, an accumulation of stresses in a rather confined zone. In addition, the welds were designed at too sharp an angle.

The trailer was fixed so that the supports were very close and slightly in front of the welds joining the third and fourth strakes.

Examination of the fracture

The fracture took place in a plane perpendicular to the axis of the tank. For part of the way, the line of the fracture followed the weld fixing the fabricated tee (which carries the baffles) to the shell. The fracture then left this weld, ran for about 14 cm. in the plate, and then followed the line of the weld attaching an exterior reinforcing plate to the shell.

In this latter area, the fracture is of a ductile type and finely grained. But, in the part which follows the weld of the fabricated tee, we found that about 1/3 of the circumference surface was dull and dark brown in color, indicating the presence of a crack prior to the accident which started from the internal surface and had a depth of 5 to 6 mm. Subsequent tests carried out on samples cut from the shell in the immediate proximity of the line of fracture revealed the following information:

Yield point .... 82.3 hectobars (53-5 tons/sq. in.)
Tensile strength .... 86.2 hectobars (56. tons/sq. in.)

Other examinations carried out using magnaflux, ultrasonic and dye penetrant methods showed that there were numerous cracks in the inner shell, particularly in the area of the circumferential welds (e.g. welds between strakes and those attaching the fabricated tee to the shell). The Office Central de la Soudure (Central Weighing Bureau) which carried out part of the tests, concluded that the cracks were caused by stress corrosion. Similar faults have been found in other tanks of a similar make that were also constructed from Tl steel.

As to the cause of the accident, one can certainly rule out the hypothesis that the tank was too full because its weight at the Lievin factory corresponded to the figure of 19 tons on the tanker document. Its volume was 38,000 litres, and the loading rate was therefore 0.50 kg./litre of capacity. The A.D.R. permits a loading of 0.53 kg./litre a value which is based on allowing a 5% margin at a temperature of 50°C. On the day of the accident at Lievin the temperature was about 22°C at noon.

In addition, a rupture caused by excess filling would have been preceded by a swelling of the shell, and it would have caused a break of a restricted nature. However, in the proximity of the break, there was no progressive variation in the metal thickness.

It is certain that on the day of the accident the tank had not been subjected to excessive pressure. In fact, after being loaded in Belgium from stocks at a temperature of –9°C, the pressure in the tank had been only 58 psig. Even after the ammonia warmed up in the morning, the pressure would not have exceeded 85 to 100 lbs./sq in. at the time of the link-up with Lievin unloading point.

In conclusion

Stress corrosion had caused numerous cracks, especially in the plane where the rupture took place, and it can be seen that corrosion had been considerable due to additional stresses in the region of the welds since there had been no post weld heat treatment of the tank. We think that the rupture was due to corrosion cracking aggravated by fatigue of the tank in the plane of the rupture, situated just above the rear wheels in an area subjected to abrupt variations in thickness.

It is obvious from the above that in the construction of road tankers it is necessary to pay particular attention to the method of attaching fixtures such as internal baffles and external stiffening beams. The choice of position for attaching the rear wheels is equally as important.

French authorities have now prohibited the use of Tl steel for storing or carrying ammonia under pressure. Containers constructed of steel with mechanical properties higher than those of Tl steel have been submitted for examination by non-destructive methods.