

Explosion of an ammonia tank

March 24, 1992

Dakar

Senegal

Food industry

Ammonia

Victims

Tank rupture

Overpressure

Organization / Procedures

Repairs / Maintenance

THE INSTALLATIONS IN QUESTION

The site:

The oilseed processing facility involved in the accident is owned by one of the largest companies in Senegal, which has the monopoly on the seed cake and peanut oil market.

The unit in question was located in the industrial sector of Dakar's harbour zone. The unit performed the detoxication of peanut cakes (through the elimination of aflatoxin) by a hexane extraction process which also uses formaldehyde and ammonia.

The ammonia is imported by boat by a fertilizer manufacturing company which is also located in Dakar harbour. The latter stores the ammonia required for its manufacturing process in three 3,000-tonne spheres, that are refrigerated to a temperature between -5 and -2 °C. Part of the ammonia is sold to the food processing plant which sends its tanker trucks to the fertiliser plant's storage installations.



THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

The accident

On March 23rd, the eve of the accident, the tank in question was loaded at 4 pm from a storage unit belonging to the fertiliser plant, then transported to the seed cake treatment plant and placed near the detoxication unit's unloading station. It was not connected as an identical tank was already being unloaded. The detoxication unit is not equipped with a storage unit specifically for ammonia; it is supplied directly from the transport tanks.

The next day at 1.30 pm, the tank suddenly burst open along the central shell which rolled out completely flat. The front and rear of the tank, while only very slight deformed, were propelled by the force of the reaction.

In a more or less horizontal trajectory, the front of the tank clipped part of the installations then smashed into the wall of an electrical service building. The trajectory of the rear of the tank is more difficult to establish. Based on the findings, it appears that it was propelled upward at approximately a 45° angle. After colliding violently with a massive reinforced concrete lintel, it ricocheted toward the detoxication installation, causing significant damage to the unit's upper levels.



Photo: R.D.



Photo: R.D.

The force of the first impact caused the running gear to separate from the tanker chassis. The axle was found in a neighbouring street roughly fifteen metres away and the second axle was thrown two hundred metres into a neighbouring establishment.

Part of the ammonia contained in the tank (22.18 t) spread into the installation. Another part, carried along with the back of the tank, was thrown outside the establishment (according to the doctors, numerous bodies found in this sector had received burns through direct contact with the liquefied ammonia).

The consequences:

A month after the accident, 116 deaths and 1,150 injured were declared; in all, the accident claimed 129 lives. The medical teams which followed up on the victims observed, as with chlorine intoxication, that individuals with seemingly minor lesions developed a fatal pulmonary oedema in the days following the accident.



Photo: R.D.



Photo: R.D.

The information collected allowed a few elements to be established relevant to the risk analysis:

1 – Liquid ammonia was projected up to thirty metres. These projections could have been greater if the back of the tank had not been stopped by the building.

2 – The whitish cloud, most likely attributed to the aerosol, spread very rapidly and developed upward. According to witnesses, the cloud moved 250 m then was "relatively rapidly reabsorbed" (within 10 to 15 min.). The description of the ammonia aerosols, observed during other accidents as being very dense and well-defined, does not correspond exactly to the testimonies gathered. The cloud was described as turbulent and allowing someone to stay in it over a distance of ten or so metres with only a handkerchief as protection. Nevertheless, the unbreathable atmosphere prevented the rescue services from intervening owing to a lack of sufficient protective equipment (masks, oxygen cylinders...).

3 – The majority of the people killed in the moments following the explosion were in the semi-confined areas of the establishment (installation, streets, and rooms where the windows had been blown out...), or in the port's restaurant sector located nearby. A plant manager who was blocked in his office for 25 minutes (as the door was jammed due to the blast from the explosion) was not injured.




4 – The "cloud" was practically reabsorbed in fifteen minutes in and along the establishments streets near the site of the accident, despite the liquid NH₃ leak caused by the ruptured hoses of the neighbouring tank that was being unloaded, and which was stopped only a half hour after the explosion. After a half-hour, the French military who were providing assistance to the Senegalese authorities, entered the establishment's courtyard without masks approximately 100 m from the accident location.

5 – There was no fire.

Despite the special meteorological characteristics at the time of the accident (temperature 28°C, high humidity, low winds with unstable direction), it appears that the risk zones were short of the forecasts given by the habitual models.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

Dangerous materials released		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The parameters that comprise these indices and the corresponding rating method are indicated in the appendix hereto and are available at the following address: <http://www.aria.ecologie.gouv.fr>

Ammonia is a substance listed in Appendix 1 of the 'Seveso' directive and has a threshold of 200 t. During this accident, 22.18 tons of NH₃ were released (representing 11% of the threshold). The index relative to the amount of 'dangerous materials released' is thus 4 (parameter Q1).

The accident resulted in 129 deaths (parameter H3) and 1,150 injured (parameters H4 and H5) which explains the high index (6) relative to the "human and social consequences" rating.

Finally, the lack of information concerning the accident's environmental and economic consequences prevents the evaluation of the last two indices of the accident scale.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The tank was built in 1983 by a French company. Its construction was monitored by the French administration and was certified in compliance with French regulations relative to the transport of dangerous materials. However, it had been repaired in 1991 after a leak was discovered during hydraulic testing. According to the findings, it appears that the tank ruptured in the location where the repair had been made.

The inquiry conducted by the Senegalese authorities established that the tank that ruptured had been overfilled several times. On March 23rd, it was loaded with 22.18 tonnes of ammonia instead of the 17.685 tonnes authorised by the tank's original specifications and the maximum filling level established by land transport regulations (TDG - 0.95). Furthermore, this load corresponds to an ammonia volume of 34.37 m³, more than 1 m³ of the tank's original volume. This confirms the previous deformations of the tank associated with the overfillings.

The time (1.30 – shift change) and location of the accident (near the industrial port's restaurant sector) are aggravating factors which partly explain the serious consequences of the accident. According to the press, certain individuals who came to investigate the source of the explosion were also among the victims.

ACTION TAKEN

In the emotional climate that inevitably follows a catastrophe of this magnitude, the local representatives of the International Labour Office and a French mission of the Classified Installations Inspectorate were able to reach the site rapidly. The very lax attitude of the Senegalese governmental authorities and the management of the establishment concerned should be noted.

LESSONS LEARNED

Following the accident, the establishment's procurement procedures underwent extensive modifications:

The ammonia is imported from Europe in 12.5-tonne containers and the maximum storage quantities at a site are:

- one container at the oilseed detoxication facility,
- a dozen containers in a storage area on property near the plant.

This new storage method offers significant greater security, owing to:

- unitary capacity less than that of the former tanks (18 t),
- filling is performed by the production plant with respect to a load limit,
- protection by rupture disk and valve,
- bottom closure valves upstream from the shut-off valves, capable of being operated remotely by cable.