Ammonia leak within a slaughterhouse

June 11, 1997

Cuiseaux (Saône et Loire)

France

Ammonia
Food processing industry
Equipment / Valve malfunction
Organisation / Procedures / Guidelines
Training / Protective gear
Automated mechanisms
Emergency plan
Atmospheric pollution
Acceptance of completed works

THE FACILITIES INVOLVED

The site:

Operations at this installation, which featured a recent design, had been partially started in 1996; the latest in a series of plant extensions, including space designated for ammonia storage, was authorised on January 9, 1997.

This plant processed 150 tonnes/day of meat (animal slaughter and production of vacuum-sealed meats, frozen ground beef, both frozen and fresh meats), with a total slaughter capacity of 450 to 500 heads of beef cattle.

The unit involved:

The facility contained refrigeration equipment operated using ammonia as the refrigerant liquid (negative cold), along with a production unit for cooling glycol water with this same fluid (positive cold).

The installations involved in the accident were gradually placed into service: animal slaughtering / cutting, and other premises operating with positive cold on January 1st, 1997; followed by the negative cold room on March 1st; and the ground beef deep freezer on May 1st of the same year.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On June 11, 1997 around 12:30 pm, ammonia began leaking inside the utility room of the shop area containing a ground beef deep freezing unit. A typical ammonia smell spread throughout the building, which was quickly engulfed in a toxic gas cloud. Several phone calls notified plant managers. At that point, the maintenance crew cut off the electric power supply, and personnel were evacuated amidst a general state of confusion and panic.

Fire-fighters were called at 1:25 pm, nearly a full hour after the accident first occurred. An inspection was carried out to ensure that no one had been trapped inside the premises. A mobile chemical emergency squad was onsite as of 2:20 pm and once again complete site evacuation could be verified. A defective valve was identified 10 min later. It took roughly 20 fire-fighters to dissipate the toxic cloud using a water curtain.

Ammonia concentrations in excess of 70 ppm were measured inside the building. At 5 pm, in noticing that this concentration was not diminishing, emergency crews decided to switch back on the power and activated the premises' mechanical ventilation system. Despite these efforts, no drop in ammonia concentration was detected even 2 hours later. Responders considered a number of hypotheses (inefficient extraction, a second leak?) and at 8:30 pm decided against restarting the ammonia circuit, preferring instead to close the site and ventilate the building throughout the night.

At the height of emergency response, 40 neighbours were confined within a 500-m safety perimeter. In all, the premises were ventilated for 30 hours. Ammonia fumes were perceptible up to 1 km away; a technician was overcome by fumes and had to be hospitalised.

The next morning at 9 am, a slight decrease in concentration was observed in some rooms, and additional forced air extraction was initiated. By 2 pm on June 12, the toxic gas concentration finally abated, making it possible to begin evaluating the condition of merchandise in stock.

Consequences of this accident:

Property damage (including products in contact with the ammonia or altered as a result of interruption to the cold chain, and the cost of transporting frozen foods) was assessed at 3.9 million francs (MF) and operating losses at 0.6 MF.

The European scale of industrial accidents:

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the '*SEVESO*' Directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices:

The parameters composing these indices and their corresponding rating protocol are available from the following Website: http://www.aria.developpement-durable.gouv.fr.

The overall level of the "hazardous materials released" index reached a 3, given that the quantity of ammonia dispersed into the environment was evaluated at 2.2 tonnes (parameter Q1: quantity between 1% and 10% of the SEVESO threshold).

The "human and social consequences" index was scored at 2, since 40 neighbours had to remain confined for several hours (parameter H7).

Due to a lack of information, the "environmental consequences" index could not be rated.

The overall level of the "economic consequences" index was rated a 2, with property damage (parameter €15) amounting to 3.9 MF and operating losses (parameter €16) estimated at 0.6 MF.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The leak, estimated at 2.2 tonnes of liquid ammonia and lasting 1 hr 45 min, occurred on a solenoid valve of the low-pressure supply circuit on the ground beef deep freezer that had begun operating a month prior. The entire installation contained 8.5 tonnes of ammonia (NH_3). The damaged automated valve (DN150) was found to be without any socket joint, instead featuring a flat joint fastened by 8 bolts. At the level of the broken joint, measurements conducted using a torque wrench indicated that 2 bolts had not been adequately tightened (poor initial clamping or gradual loosening either subsequent to pressure surges or as a result of temperature and pressure variations?); experts suggested ensuring clamping by means of locknuts. This newer joint had replaced an asbestos joint, which was no longer being allowed.

The exact cause of this accident could not be determined (hidden defect, noncompliance, poor design, flawed assembly?). Expert appraisals also uncovered that the alarms had not been relayed to the double-threshold detectors (300 and 2,000 ppm), in addition to a lack of coordination at the facility management level.

The quantity of ammonia released was considerable despite the presence (both upstream and downstream of the defective valve) of fail-safe electric valves (featuring a detection servo control yet still capable of being manually forced open or closed) that should have closed at the time of the leak. If these valves had been operating properly, the ammonia leak should never have exceeded the quantity of refrigerant found in the ground beef deep freezer, i.e. 450 kg. The estimations derived by experts, which were much higher although consistent with the quantity of ammonia loaded into the unit (i.e. 2.2 tonnes), suggest that a source was feeding the leak. Experts explored the hypothesis of a manual opening prior to the accident on the upstream valve, reflecting on the possibility of incomplete closing afterwards, thus limiting efficiency of the fail-safe mechanism. No explanation was forwarded regarding how this valve may have opened,

though handling was restricted to circuit initiation (an operation performed at the beginning of May '97). While the operator would not suggest it, the possibility of a subsequent manipulation cannot be ruled out.

The investigation revealed that the extraction hatches for discharging ammonia from the building were inoperable due to a poor electrical connection. A debate was held among the various parties involved in onsite operations regarding the role of the facility manager, who would have proposed several dates for final testing only to systematically have the schedule postponed by the facility owner. Consequently, on the day of the accident, these tests had still not taken place, although site installations had gradually been placed in operation.

ACTIONS TAKEN

Several conditions outlined in the January 9, 1997 facility operating permit had not been respected:

- √ The internal emergency plan had not been validated by the Departmental Fire and Safety Office and moreover the existing project did not include any written guidelines for implementing response measures, evacuating employees/residents, and calling on external rescue services;
- √ The site's sound alarm was not servo-controlled to the NH_3 detectors;
- √ The study used to define the number and placement of NH_3 detectors did not give rise to a satisfactory detection apparatus as regards personal safety;
- √ Individual protective gear was insufficient;
- √ Personnel training relative to NH_3 safety was also inadequate.

On June 18, 1997, a Prefectural order was issued to confine use of ammonia to a single zone within the facility and imposed a comprehensive inspection of the NH_3 circuit. The site resumed operations 5 days later.

LESSONS LEARNT

This accident provided several lessons regarding technical and organisational aspects:

- √ The need for a reliable installation, featuring an effective facility management component (detectors in sufficient quantity and strategically located, an alarm servo-controlled to detectors, operable extractors), and works supervision and acceptance testing;
- √ A required operational internal emergency plan (including personnel training, well adapted and adequately stocked protective gear, accurate indications of circuits and valves, repeated evacuation drills necessary to sharpen reflexes, coordination of onsite teams);
- √ Effective identification and recording of high-risk zones, even if the risk is only occasional (e.g. attics, spaces reserved for pipes carrying hazardous liquids).

*Fire-fighters on the scene (from the magazine "*Sapeur pompier*", October 1997 issue)*