Ammoniac leak during unloading of a railway wagon.

16th December 1994

Mazingarbe – [Pas-de-Calais] France

Chemistry
Toxic releases
Valves
Anti-collision pedal Automation
Organisation / Maintenance
Internal / public emergency plans
Confinement

THE INSTALLATIONS CONCERNED

The site :

The chemicals platform of 180 ha, at Mazingarbe (62) near to Lens employed 200 people. It had a production capacity of 550 000 t/year (1 500 t/j) of nitrate fertiliser and 1 200 t/j of nitric acid.

Subjected to the SEVESO directive, the plant had an internal operations plan (POI or plan d'opération interne) and, since 1992, it has conducted an information campaign directed at the public, in the framework of a public emergency plan (PPI or plan public d'intervention).

The installation :

The ammoniac arriving in railway tank wagons, was stored in a sphere of 1 780 t. The plant has three discharging points to unload the 50t wagons. Authorised under the terms of classified installations, these points had been subjected to a study of the dangers and, since October 1990 to special regulations.

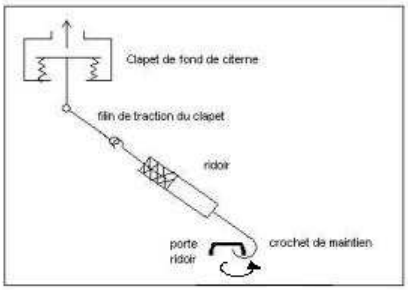
Sources : D. Fulleringer – Evaluation de la sûreté des installations utilisant de l'ammoniac

Each fixed point which had a transfer capacity of 1 t of ammoniac per minute, comprises piping for the liquid phase and piping for the gas pause. Linked to the sphere, they were equipped with an automatic security valve and a manual valve.

The tank wagons had equipment for filling and draining composed of two pipes sealed by manual valves and equipped with internal security valves for:

- the liquid phase, connected to the bottom of the tank,
- the gas phase, connected to the top of the tank by internal piping.

The valves were maintained in the open position by a turnbuckle hooked to one side of the valve cable and on the other side by the turnbuckle support. This latter was equipped with a pneumatic control, its operation was automatic. Thus the lack of air in the chamber with the gas strut caused the rotating turnbuckle support to swing around by 90° causing the unhookin g of the turnbuckle and the closing of the wagon's internal security valve.



The connection between the tubing of the tank wagons and the fixed pipes the filling points was made with articulated transfer arms equipped with automatic disconnection devices and closing valves.

To avoid the consequences of a collision with a moving wagon, the discharging tank was protected on both sides by a detection device (electric pedals located about 10 meters away) causing the automatic disconnection of the discharge arm and the placing in security of the installations by the release of the turnbuckle in the event of the arrival of a wagon.

THE ACCIDENT, THE SEQUENCE OF EVENTS, ITS EFFECTS AND ITS CONSEQUENCES

The accident

On the 16th December 1994, at 5:20 p.m., a wagon had been in the process of discharging at point 3 for 2 minutes when the loading arm suddenly disconnected. A leak of the liquid phase occurred at the extremity of the half or the arm which remained attached to the wagon. Under the pressure of the jet the random movements of the arm with its two articulations caused the rapid formation of an aerosol in the unloading zone, making access difficult. Furthermore, the thrashing of the arm damaged the joints located above and below the drainage valve of the wagon, creating secondary leaks a few minutes later.

Alerted by the noise of the disconnection of the arm, the employees donned their protective masks and proceeded to the control room to sound the alert. On the way they activated on several occasions the emergency stop (pressure buttons) without this having any effect on the leakage.

The plant initiated its emergency plan (POI) around 5:30 p.m. An employee began to equip himself with water-proof overalls. At 5:45, external emergency services were alerted and plant employees stopped the traffic on a nearby road.

At 6 p.m., another employee, equipped with a mask, went around the ammoniac cloud and succeeded in unblocking the turnbuckle for the unloading point, located around 15 meters away, by throwing a metal block at it. The bottom valve of the wagon closed and thus the main leak was mastered.

Outside help then arrived on the scene. The neighbouring population was advised by loudspeaker cars, to remain indoors.

The public intervention plan (PPI) was initiated at 8:45. The main leak having been mastered, only the operational emergency services were required and not all the procedures are applied (neither siren nor broadcast message). Traffic was forbidden in a radius of 2.2 km around the plant in accordance with the worst scenario of the PPI. Ten first aid centres were set up. For 4 hours, 80 firemen intervened with 25 vehicles, ambulances and a mobile chemical intervention cell (CMIC). The population of Bully and of Lens were invited to remain indoors. People were also confined in a school and a supermarket and then were evacuated when the cloud dissipated.

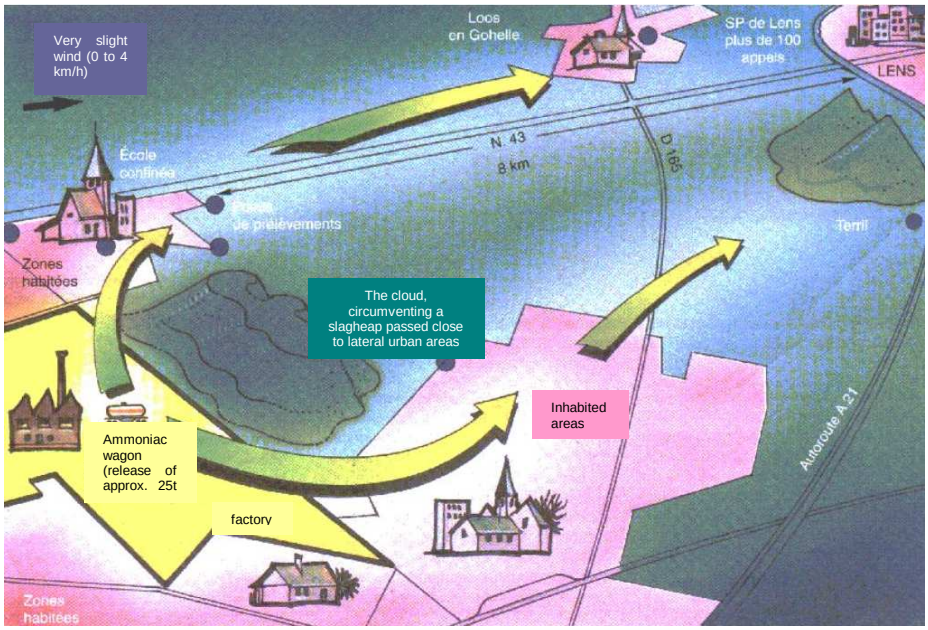
All danger was passed towards 8:30, measurements of concentrations of ammoniac in the neighbouring towns and villages then gave results lower than 5 ppm. The PPI was lifted at 20:40 and the toxic releases ceased around midnight once the bolts around the valve strap had been re-tightened.

The consequences :

Dispersion of the cloud

When the accident occurred, the meteorological conditions were very unfavourable as regards the dispersion of the ammoniac cloud.: very slow dispersion (thermal inversion) unstable wind from the north by north-west… According to the first witness statements, a dense fog was formed at about 3m above the ground and rose slowly into the atmosphere. The cloud then moved towards a national road (RN 43) and the closest houses.

The wagon contained initially, 48t of ammoniac, 18 t were found in the tank after the accident. Approximately 27 t of toxic substance were thus released to the atmosphere in 37 mm (average flow rate of 12 kg/s).



Crédits : René Dosnes

According to the emergency services, the smell of ammoniac (concentration of 5 ppm) could be observed as far as 8 km from the point of release to the south-east (preponderant direction of the wind) covering a cone of around 70°. Furthermore a slagheap between Grenay and Mazingarbe forced the cloud to slide around its flanks and divide into two parts of which one then moved to the south-east. Thus, 300 telephone calls, mainly requesting information, were recorded by the emergency centres of Bully-Mazingarbe (50 calls), Liévin (100 calls) and Lens-en-Gohelle (150 calls). With the help of these telephone calls, witness statements and occasional measurements made between 20 p.m. and 20:30, the geographical zone affected by the cloud could be defined.

Human consequences

The security measures put into effect concerned between 8 and 10 000 people. In this context, the low incidence of human consequences observed, given the quantity of ammoniac released, is surprising:

- A little girl of two years of age and presenting respiratory problems was admitted for consultation at the University hospital of Lens and was released 2 h later.
- One person who was inconvenienced by the cloud was treated at around 18:15 at his home in Mazingarbe.
- Finally, 15 telephone calls were recorded after 18:45 at the anti-poison centre of Lille. They came from people who were affected (prickling of the eyes and the lips) mainly resident in Loos-en-Gohelle. These people wanted information concerning the risks associated with ammoniac. There was no other victim to be reported.

The sensible behaviour of the neighbouring population following the accident is certainly one of the reasons which explains the limited human consequences. In this regard, the initiation in May-June 1992, of an information campaign on the mastery of technological and industrial risks proposing, in particular, the organisation of "open days", the distribution of leaflets to create awareness and the setting up of information sessions in CM2 classes (children 10 -11 years old) probably played a considerable role.

European scale of industrial accidents

By using the scoring rules for the 18 parameters of the scale approved in February 1994 by the Committee of Competent Authorities of the Member States for the application of the 'SEVESO' directive and taking into account the available information, the accident can be characterised by the 4 following indices.

The parameters included in these indices and the scoring methods can be found at the following address: http://www.aria.ecologie.gouv.fr

The 27 t of ammoniac involved in the accident represent 13% of the Seveso threshold associated with this toxic substance (toxic : 200 t) which explains that the index for "dangerous materials released" is at 4 (parameter Q1). The index for "human and social consequences is at 4 because nearly 8 000 people had to remain confined indoors for 3 h (parameter H7).

THE ORIGIN, THE CAUSES AND CONSEQUENCES OF THE ACCIDENT

The disconnection of the unloading arm and the blocking in the open position of one of the two security valves forming part of the disconnection system were at the origin of the accident. These events resulted in the combination of an initiating element and the malfunction of two elements of the security system of the installation:

- **The initiating element: anti-collision detection**

For an unknown reason, (vibration, shock on the wagon, passing by of a person…) the sudden activation of the anti-collision system provoked the

Sources : D. Fulleringer – Evaluation of the security of installations using ammoniac

disconnection of the loading arm of loading point 3. On the track serving this loading point, the manoeuvre consisting of distancing two empty tank wagons which had previously been unloaded had just commenced. Subsequent checks of the anti collision pedals did not reveal any malfunction.

- **Failure of the system to free the turnbuckle activating the bottom valve of the wagon**

Following the order to disconnect the unloading arm, the bottom valve of the wagon did not close on account of a malfunction of the turnbuckle and its activating pneumatic system. This occurred for two reasons:

- One mechanical reason, the turnbuckle remained blocked on the catch of the turnbuckle support, doubtless on account of the acute angle between the turnbuckle and its support.

- A second reason linked to the problem of automation: the order to switch the turnbuckle is maintained only during the closing of the security valve of the sphere (around 3 s) by design of the automatic sequences of the security automation. The turnbuckle holder returned therefore to the blocking position as soon as the valve on the sphere had been closed.

This latter anomaly partly explains why the several attempts to activate the emergency stop had no effect on the leak, the safety sequence of the unloading point (release of the turnbuckle, disconnection of the arm) piloted by the automated system was only activated when two conditions are simultaneously observed:

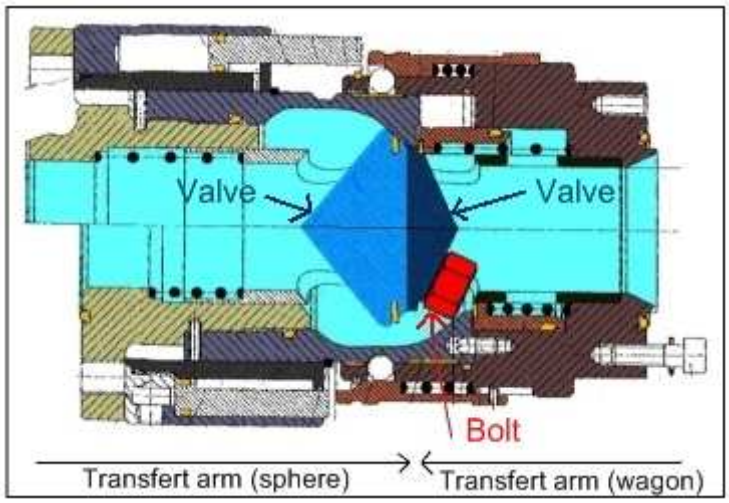
- Security valves on the sphere open,

- Emergency stop activated.

The bottom valve of the wagon, when it could finally be activated 40 minutes after the leak had commenced, worked correctly.

- **Failure of the valve (wagon side) of the disconnection system of the transfer arm**

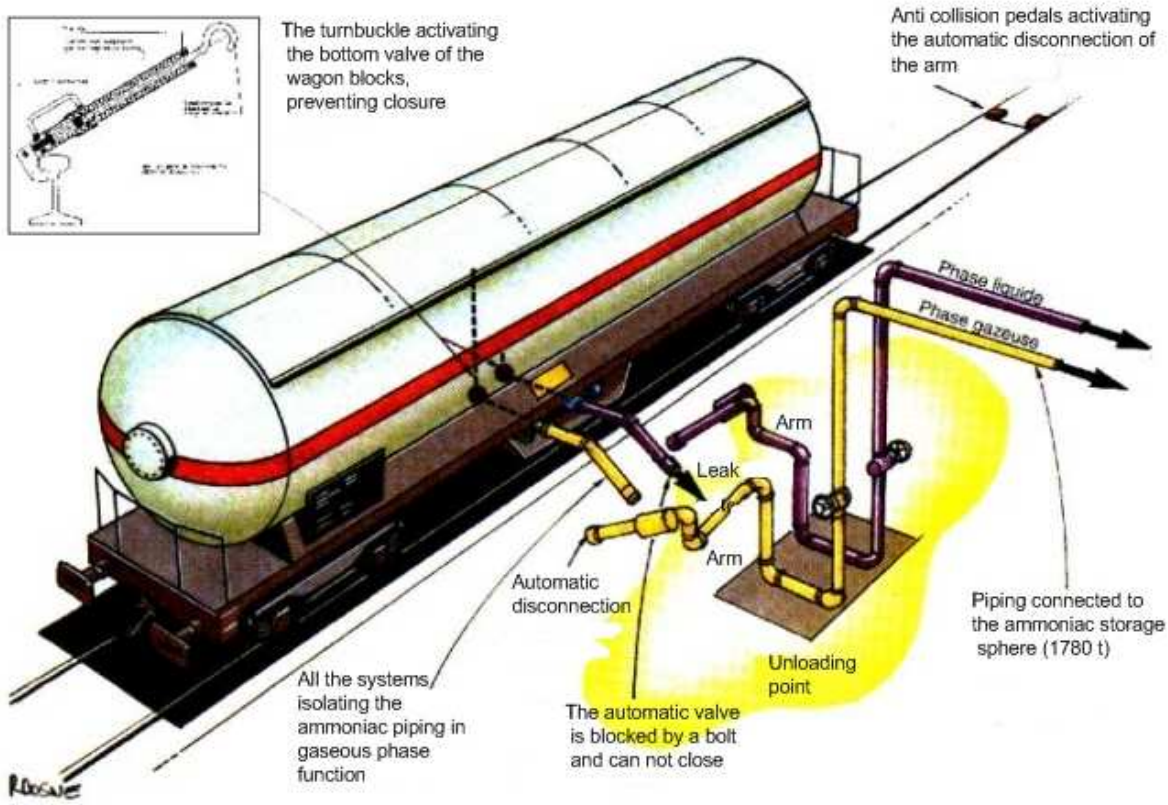
The valve of the disconnection system mounted on the transfer arm (on the wagon side) only partly closed, blocked by the presence of a foreign body: a bolt of unknown origin and different from those used to attach the straps on the unloading installation (see figure below).



Source : DRIRE Nord-Pas-de-Calais

Furthermore, the second leak of ammoniac which occurred a few minutes after the sounding of the alert, at the level of the joint between the valve and the distribution pipe of the wagon, resulted from the progressive loosening of the straps induced by the jerky movements of the segment of the arm connected to the wagon under the pressure of the ammoniac escaping from the tank. Other leaks observed at the level of the joint above the valve (which had closed in the meantime) provide evidence of the lack of air tightness of the bottom valve.

Finally, it should be mentioned that the valve of the segment of the arm connected to the sphere functioned correctly, preventing the sphere from leaking.



Crédits : René Dosnes

THE MEASURES TAKEN

Following the accident, unloading was suspended until the plant had determined the precise causes of the failures observed and had proposed solutions to remedy these. A few days later the operator proposed several measures which were confirmed by a third party expert:

- Modification of the emergency stops which would henceforth have mechanical hooking and would require electrical rearming to be put back into service after being activated, thus allowing for the time required for the placing in safety conditions of the unloading point.
- Installation of fail-safe pneumatic safety turnbuckles in place of the" turnbuckle + turnbuckle support" system and instructions given for regular testing of the turnbuckles to regularly verify their correct operation (1 test per point for 8 h / unloading point).
- Placing of two 15 m cables on the turnbuckle, allowing, in the worst case, for remote manual activation of the bottom valves of the wagon.
- Disconnection of the transfer arm would be henceforth limited to the only event of the movement of a wagon being unloaded, in order to limit the possibility of unexpected disconnection.
- Padlocked swinging Scotch blocks making it materially impossible for accidental collisions between unloading and other moving machines, to replace the disconnection pedals used at the time of the accident with the tank-wagons.
- Placing of a filter at the end of the liquid phase arm on the wagon side, to prevent the intrusion of foreign bodies.

To complete these dispositions, temporary orders were given to the plant while awaiting the completion of a global study on the failure of the unloading system. The plant re-commenced activities on January 5th 1995 at 10:00 a.m.

THE LESSONS LEARNED

This accident fortunately had limited consequences as regards the population and the environment. It nonetheless corresponds to one of the major scenarios to be envisaged relating to an unloading installation and shows moreover that:

- A serious accident is always possible, even where there are a sufficient number of redundant security measures. It should be noted here that the conjunction of human error (introduction of a bolt into the ammoniac circuit) and the presence of a disconnection valve which is at the origin of a massive leak, whereas this valve is supposed to prevent leaks when the transfer arm is stretched (see: accident at the LPG depot on 23rd October 1989 at Le Blanc (36)).

- Checks must be performed following maintenance (detailed inspection of the installation or of the repaired equipment, counting of the parts before and after the works…) the company had already been the victim of this kind of failure a few months previously (4 bolts had been found in a tank) after maintenance work. There seems to have been nothing learned from the experience of this kind of incident.

- Even if he is not alone, it takes at least 15 to 20 minutes for an operator to don protective overalls.

Furthermore, this accident is rich in lessons on good practice to be adopted where automated procedures are used, in particular:

- Prefer fail-safe automated systems,

- Multiply security systems while avoiding their having common failure modes,

- Where possible, maintain 1st fault tolerance and the associated safety functions,

- Prefer automated systems which can be tested as from the design stage and following modification and then periodically,

- Adapt the automated systems to the operators, particularly where there are semi-automated systems – and not the reverse,

- Describe the intervention procedures in the event of failure of the automated system.

- Training for operators on procedures for intervention in a deteriorated situation.