Wall rupture of a cereal storage silo and "domino effect" on a propane tank

August 19, 2008

Saint-Hilaire-sur-Puiseaux (Loiret)

France

Hazardous discharge
Food processing activity
Silos
Fixed storage (tank)
Cereals / liquefied gas
Rupture
Fatigue / Ageing
Preventive inspection
Organization

THE FACILITIES INVOLVED

The site:

The company operates a cereal complex within the municipality of Saint-Hilaire-sur-Puiseaux in a hamlet named "La Bonnette" ; this complex contains:

- ✓ a silo made in 1989 of interlocking sheet pile with a capacity of 14,933 m³,
- ✓ an aboveground, 95-m³ propane tank,
- ✓ a 9-MW cereal dryer that runs on LPG.

These installations fall within the jurisdiction created by environmental protection legislation for classified facilities; the company has been granted a Prefectural authorisation to operate, dated July 7, 1989.

The closest entities to this operation are:

- ✓ another cereal complex located some fifty metres down the road in the hamlet named "La Breuille". This activity is run by the same company and falls under the classified facilities jurisdiction as well; it is composed of installations similar to those at the site of the damaged silo:
  - o a 7,150-m³ capacity silo made of interlocking sheet pile,
  - o a 70-m³ LPG tank located approximately 1.5 m from the silo,
  - o 2 cereal dryers each with a 5-MW power rating.
- ✓ a farm located about 300 m away,
- ✓ the town of Saint-Hilaire, at a distance of more than 500 m.

The involved unit:

The cereal storage silo (L = 34 m, W = 26 m and H = 28 m to the silo ridge) is composed of 6 cells each 16.5 m high:

- ✓ two square cells (8 m x 8 m), containing 1,400 m³
- ✓ four square cells (13 m x 13 m), containing 3,000 m³
- ✓ two 66-m³ bushels.

The propane tank, which lies onsite and serves to fuel the dryer, is located some 15 metres from the silo walls.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

2,100 tonnes of wheat and 1,000 tonnes of corn spread over a distance of roughly 15 metres following the wall rupture on cells 3 and 5, each with a 3,000-m³ capacity, causing partial collapse of the propane tank installed in the vicinity.

This overflow of grains caused the tank to move laterally and in turn burst the LPG pipe (in gaseous phase) between the tank and the relief valve; the flow limiter positioned at the level of the tank was closed yet retained a minimum leak that was sealed off when fire-fighters closed the valve placed on the pipeline located upstream of the rupture.

The safety perimeter, established by the emergency services team upon arrival on the scene, was kept in place throughout the period of both tank unloading and gas flaring performed by the company owning the tank, at the request of the silo operator. This mission began around 6:00 pm on the day of the accident and was completed by 5:00 am the following day.

The inspection authorities for classifield facilities were informed the same day at 1:30 pm by the Interministerial Defence and Civil Protection Agency (SIDPC) of the onsite intervention of French departemental fire service (SDIS unit).

Damaged silo (source: DRIRE)

Consequences of this accident:

Only property damage was declared; no impact on the personnel, third parties or the environment was observed.


Source DRIRE


Source DRIRE


Ruptured pipe (source: DRIRE)

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 the 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

Level 1 of the "Dangerous materials released" index characterises the discharge of propane, a gas listed in Appendix 1 of the *SEVESO* Directive, although the lack of detail regarding quantities emitted prevented refining this estimation any further.

The accident had no human, social or environmental consequences and thus did not require rating any of the corresponding indices.

The "economic consequences" index (parameters €16 and €15) could not be distinguished given the absence of any damage estimation.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The accident was related to the rupture of silo walls due to both the state of structural fatigue and a drop in cereal stock along with the partial tank collapse, thereby causing a gas leak. A flaw had been detected by the operator during silo construction in 1989, triggering the need for structural reinforcement works on the site in 1990.

A slight leak of cereal grains had been noticed the day before, and on the day of the accident the operator had already begun transferring grain, at a slow flow rate, from the damaged cell to an intact one. The rupture occurred one hour after this operation got underway.

The cause of this accident might have originated from the rupture of silo walls, which had not undergone any special monitoring or inspection for signs of structural ageing, under the effect of fatigue and the weight of moving cereal stocks.

According to the owner of the damaged propane tank, the gazeous leak on the tank was contained by the automatic closure of the internal limiter, and the same would have applied in the event of rupture before the valve.

ACTIONS TAKEN

The Inspection authorities for classified facilities conducted a field visit of the "La Bonnette" site and of the neighbouring silo on the "La Breuille" site the day after the accident.

The primary physical damage was recorded by inspectors accompanied by the site operator.

Besides shutting down activities on the site of the accident, a Prefectural order of emergency measures, dated August 22, instituted security measures for the damaged installations, focusing in particular on the following:

- ✓ 1 – Site closure
- ✓ 2 – Inerting the LPG tank
- ✓ 3 – Onsite monitoring
- ✓ 4 – Verification of silo structural condition
- ✓ 5 – Drainage of all silo contents
- ✓ 6 – Issuance of a burning permit
- ✓ 7 – Service start-up only after expert review.

Measures 1 through 6 above were carried out. The expert evaluations to restore the silo structure are currently underway by various engineering consultants commissioned by both the operator and insurers.

During their site visit, the Inspection authorities for classified facilities highlighted the following:

- ✓ regarding the silos: absence of any formalised approach to implementing the facility monitoring programme with a frequency adapted to the age and structural condition, as a means of preventing the risk of collapse or rupture to the cereal storage capacities, in addition to a lack of effective protection against lightning;
- ✓ concerning storage facilities for liquefied flammable gas: the sprinkling system was not hooked up to or servo-controlled by a gas detection device, absence of adequate water resources or insufficient water capacity, no safety or operational guidelines adopted, no storage logs, absence of justification for overfilling prevention.

And yet these specific points were each addressed in the Ministerial order dated December 28, 2007 for cereal storage silos that lie within the scope of application of the August 23, 2005 order as regards depots of liquefied flammable gas under this jurisdiction.

Moreover, the inspectors' report noted a perforation in the sidewall of a cell on the neighbouring "La Breuille" silo, indicating the presence of corrosion at the level of its basic structure.

As for the "La Breuille" site, the operator was addressed a formal notice to enter into compliance via Prefectural order dated September 26, 2008; moreover, the facilities inspection office requested the operator to incorporate feedback and lessons gained from the accident occurring on the "La Bonnette" site.

Beyond the specific requests submitted to the operator, the companies owning the LPG tanks on the two sites were asked to specify:

- ✓ the characteristics of tanks as well as safety equipment;
- ✓ their proposals for reducing the probability of such an event;
- ✓ their suggestions regarding LPG tank safety features, especially with respect to isolation devices (if the rupture had occurred before the valve or if the valve had been damaged, could the leak have been stopped? does the flow limiter actually suffice? would this device be the most suitable?), recognizing that valves are external devices and flow limiters do not serve the purpose of totally stopping leaks;
- ✓ the measures adopted by these companies in order to ensure that their LPG tanks are being operated in accordance with mandated safety conditions and current regulations.

On the still intact "La Breuille" site, the LPG tank was inerted; the tank will be placed back into service once it has been moved and once a new notification has been approved by the SDIS unit on dimensions of the fire water backup capacity.

The other remedial actions underway include:

- ✓ drafting of a set of safety guidelines specific to LPG storage,
- ✓ verification of all electric installations,
- ✓ a lightning study initiated with the intention of introducing, depending on the study's conclusions, a protection system,
- ✓ expert evaluation of the silo's structural condition.

A calendar of works necessary to restore all ancillary installations to the level of their contractual specifications is to be submitted to inspection authorities.

LESSONS LEARNT

No noncompliance was recorded relative to regulatory safety distances (standard order 211), even though the LPG tanks located at a distance of 15 m (on the site of the accident) and 1.5 m from cereal storage facilities lie within the silo collapse boundaries.

This accident, which was presented to national LPG and silo working groups, has revealed both the possibility of modifying the regulatory distances between various kinds of installations with special declaration requirements (such as LPG and silos) and the importance of conducting regular monitoring of installations in order to combat ageing effects*.

For silos requiring approvals authorisation (i.e. capacities over 15,000 m^3), the regulatory procedure actually requires, as part of the hazard study, incorporating and impeding "domino effects", particularly as regards safe collapse distances.

A logic diagram for structural durability audits, intended to prevent the risk of silo collapse, was also proposed at the end of 2008 by a professional farming organisation.

** Article 3.7 of Appendix 1 of the Ministerial order issued December 28, 2007 applicable to installations in existence as of August 3, 2008*

A working group was formed within a professional LPG committee on the risks and procedures for locating tanks containing liquefied flammable gas used in the agricultural sector, with the aim of proposing additional preventive measures. On this last point, one of the committee members has already indicated that all storage facilities used in the liquid phase would gradually be equipped with a manually remote-controlled mechanical shutoff device.

The commitment of LPG tank owners, within the scope of an organised entity that enables ensuring their facilities are being operated in accordance with all required safety conditions, would appear to be a highly desirable next step.