Explosion of dust in a silo

14th May 2001

Albert – [Picardy] France

Explosion
Food processing
Silo
Maintenance / Works
Organisation
Victims

THE INSTALLATIONS IN QUESTION

The site :

The company, which was installed on the site in 1989, is specialised in the production of animal feed : cereals, cattle cake… The raw materials are stored in silos before being milled and mixed. Finished products are then shipped in bulk or in bags.

The site is a classified installation authorised by decree from the prefect dated 19th June 1989, for the storage of cereals and the milling, crushing and mixing of vegetable substances. It is not covered by the SEVESO directive.

The installations comprise the following :

- horizontal brick silo with a capacity of 5,460 m³
- vertical concrete silo for raw materials with a capacity 2,000 m³
- horizontal metal silo with a capacity of 6,000 m³
- de-commissioned metal silo with a capacity of 730 m³
- production workshop with bulk loading tower having a capacity of 308 m³.

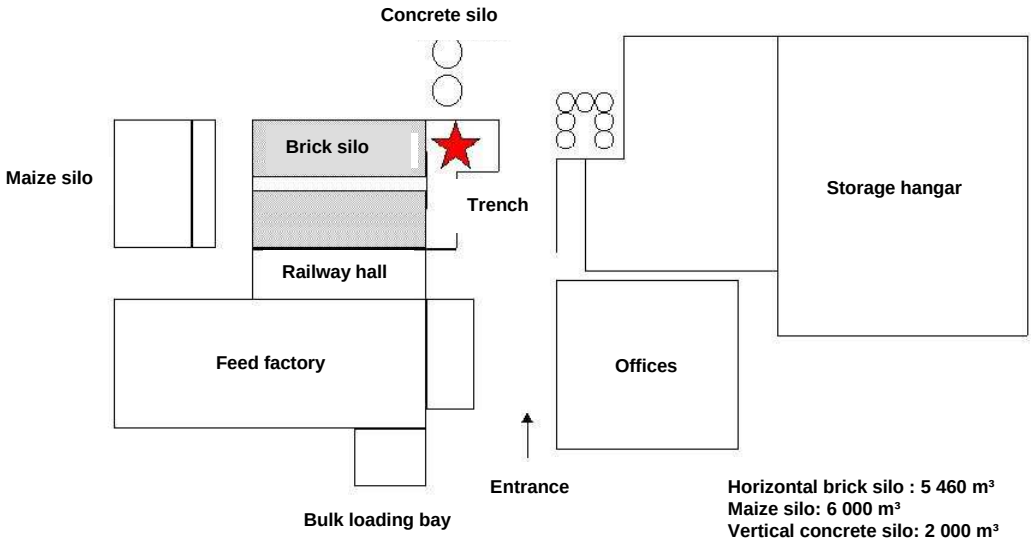
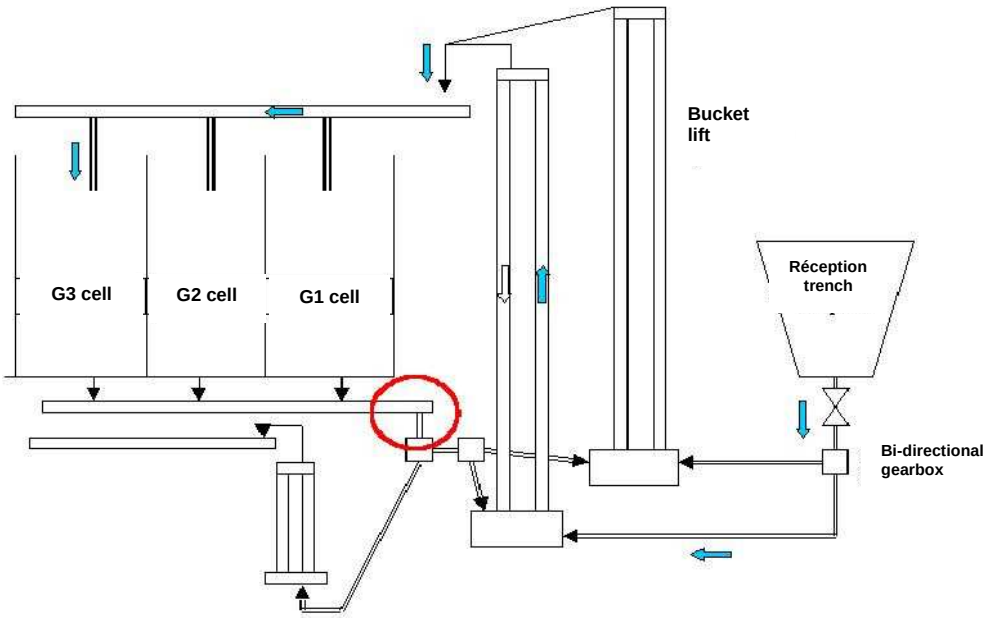


Diagram of layout of installations – Indication of locality of the explosion

The unit involved :

The damaged horizontal brick silo includes a reception/shipping area, a handling tower, the storage, the roofing and two underground overflow galleries.



The storage space is composed of two lines of 6 and 9 cells, completely open and separated by a corridor of roughly 2 m width and extending up to the total height. The cells are built with composite materials with reinforced concrete framing filled with hollow bricks. They are located in a metal structured building with walls and roofing in metal sheeting and plates of fibro-cement.

The reception/shipping point backs onto the gable of the silo without communication to it. The roofing and the side walls are made of steel cladding on metal frames. It is totally open on one side. The receiving conveyor belt is buried. It communicates by gravity with the base of the bucket lift located in the handling tower.

The handling tower, 20 m high, is provided with two elevators. It includes at the bottom, a trench composed of reinforced concrete walls and, on the upper part, a light structure built of galvanised corrugated iron assembled on metal framing. The roofing is composed of corrugated fibro-cement on metal rafters.

Materials handled in the unit are cereals and cattle cake. The handling of these systematically generates deposits or blowing dust. These dust clouds may become explosive in the presence of a source of heat.

THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

The accident :

On the 14th May 2001, around 10 h, a lorry arrived at the plant to deliver 29 tonnes of colza cattle cake. The driver began the operation of unloading into the reception trench of the brick silo.

At the same time, two operators came to initiate works on the Redler conveyor for evacuation of the brick silo, to repair the drive chain of the scrapers. To do this, they removed the hood located at the end of the Redler at the trench end, cut up and welded the links in the chain.

A violent explosion occurred around 11h15 within the handling tower.

The lorry driver, standing in front of the unloading bay was slightly burned. The two operators, located on the trench, were seriously wounded, (3rd degree burns). One of the operators succeeded in climbing out of the trench by himself. He pressed the emergency stop button for the handling installation. His colleagues sat him down on a chair to await the arrival of the emergency services about ten minutes after their call. The other operator remained unconscious at the bottom of the trench. He was extracted ½ an hour later by the firemen.

The explosion, heard in the neighbourhood, was followed by fires in the trench, in the grain tank and in the tower and gallery spaces above the cells.

The hot gases and/or burning particles, caused the ignition of deposits of dust in the ventilation systems of the cylindrical silos located a few meters away but at a higher level in the horizontal silos. The firemen, alerted by the smoke trails, intervened rapidly to put out these fires, thus avoiding the propagation of the flames to the vertical cylindrical cells.

Photo D.R.

Photo D.R.

The consequences :

The two workers performing the maintenance operation in the trench of the handling tower were seriously wounded, one of them died a few weeks later ; the lorry driver delivering the colza cattle cake was less seriously wounded.

Material damage was serious. The explosion blew off half the surface area of the roofing of the silo and gutted the walls of the handling tower. Pieces of fibro-cement plates from the roofing were found 30 m away and the metal struts for the access stairway were sectioned.

The descending conduit of the bucket lift was blown away and opened over a length of nearly 4 m below the ground as well as over two thirds of the height of the tower.

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, taking into account the available information.

The parameters comprising these indices and the corresponding method of scoring can be found at the following address : http://www.aria.ecologie.gouv.fr.

The effects of the explosion not having been characterised and the estimation of the distance of broken windows being less than 330 m, parameter Q2 of the index for the release of dangerous substances is scored at 1.

The level 2 reached by the index of "human and social consequences" is due to the death of an employee as a result of his wounds (parameter H3).

In the absence of information, the index “economic consequences” is not given a score.

THE ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The origin of this accident is linked to the failure to respect the elementary rules for accident prevention in cereals storage sites.

The cleaning of the premises had not been performed. Large quantities of cereals and dust had accumulated in the trenches, on all surfaces, the thickness of the dust layer was several centimetres.

Photo D.R.

Portable grinder found on site

A maintenance operation requiring welding and grinding was undertaken in a confined space. A fire permit was signed for the form but no cleaning was undertaken. The workers intervened on the Redler conveyor while the bucket lift was in operation. Inside this, the air was saturated with dust.

The emptying of the lorry was almost completed and the work of welding and grinding was finished when the explosion took place.

Investigations undertaken on the site took particular account of the electrical conductivity of the metallic masses. Analyses and laboratory measurements eliminated the possibility of a reaction within the cattle cake being unloaded as well as that of significant quantities of residual hexane. Mechanical tests were also conducted on the parts of the ducting blown away.

Following analysis of the elements gathered on the site, the probable scenario of the accident is as follows :

- ✓ Initially projections of metal caused by the grinding work fell :
  - × either to the bottom of the trench, causing one or several points of ignition,
  - × or into the channels of the Redler conveyor prior to coming into contact with the dust filled atmosphere of the descending arm of the elevator.

Holes, which would have allowed such a passage, were discovered in the switching and directing gear between the various pieces of handling equipment.

- ✓ Following this
  - × a primary explosion occurred in the descending ducting of the elevator at the level of the trench of the handling tower,
  - × this extended to cover the full extent of the trench by the effect of the dust in suspension present there,
  - × the rupture of the descending elevator ducting at level 2 of the handling tower, due to over-pressure, propagated the deflagration throughout the tower,
  - × in parallel, the explosion in the trench affected the upper part of the tower, via the openings,
  - × the explosion of the tower was diffused towards the entire storage building and the attics.

The trench where the accident took place is the strategic centre for handling where all the circuits for filling and extraction of products meet and serve all the silos of the company.

The operator believes that the cause was the blockage of a rotating part in the damaged elevator which could have heated up and caused the explosion.

ACTIONS TAKEN

Administrative actions :

An urgent order from the prefect dated 16th June 2001 decreed, for the resumption of activities :

- ✓ the prior submission of an updated study of the dangers of the site, in conformity with the dispositions of article 3 of the decree of 21st September 1977,
- ✓ proof from the operator of strict compliance with the regulatory requirements in force for all installations involved in the reception, handling, storage and transformation of cereals and cattle feed,
- ✓ transmission to the prefect, as regards the damaged transfer chamber, of the report required by article 38 of the decree of 21st September 1977, indicating the conditions under which the appropriate measures had been taken to ensure the avoidance of any repetition of such an accident.

The company submitted a study on the dangers on 28th June 2001 and subsequently justified, stage by stage, the strict compliance of its installations. Progressively, the re-starting of operations in the “brick” and “maize” silos were authorised.

Legal actions :

The manager of the establishment was convicted in the appeal court on December 22nd, 2004 and condemned to 30 months prison of which 6 months firm and the rest suspended and a find of 2 000 €. His appeal to the supreme court was rejected on November 22nd, 2005. The company, as a legal entity, was condemned to a fine of 59 000 € on appeal.

LESSONS LEARNT

On the site, preventative measures have been taken on the site of the damaged trench :

- ✓ Simplification of the equipment for the connection of the of the silos,
- ✓ Installation at the head of the new elevator of an explosion venting on the whole surface in contact with the exterior ; the feet of the elevator are equipped with surfaces which can be blown clean,
- ✓ Replacement of the concrete flooring of the ground floor level of the brick silo, corresponding to the ceiling of the elevator trench, by spread metal flooring,
- ✓ Placing of a separating door between the reception trench and the galleries beneath the cells,
- ✓ placing of “steel box” cladding to separate the handling tower and the upper part of the cells in order to limit, on the one hand, the access of dust to the tower and, on the other hand, to limit the propagation of a secondary explosion in the event of an accident.

Furthermore, a position for a security manager has been created in the company.