

Explosion of a fireworks fabrication and storage facility

June 01, 2004

Villeneuve sur Lot (Lot et Garonne)
France

Domino effects
Pyrotechnics
Explosives
Fireworks
Homemade
Organisation
Safety data information package
Bulk
Victims
Property damage

THE INSTALLATIONS IN QUESTION

The establishment is specialised in the fabrication and storage of fireworks. The facility is located on 8 ha of land on which approximately 30 buildings have been erected. Some of the buildings have several rooms. Ten of the buildings are reserved for fabrication operations and 20 are dedicated to storage.

The establishment is classified SEVESO ("AS" high threshold with public easements) owing to the storage of explosive substances (16 t for an "AS" threshold of 10 t). In application of the French texts, which transpose the European "Seveso II" Directive, the facility is subject to the provisions concerning the "high level" Seveso threshold of said Directive.

The site has been in operation since 1976 and the current operator has been in place since 1995. On the day of the accident, 6 people were working at the site.

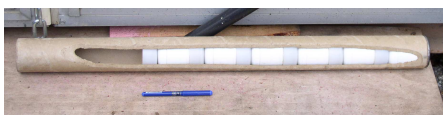


Photo : R. D.

The establishment manufactures a wide range of homemade fireworks. The pyrotechnic materials used or manufactured essentially consist of binary mixtures of combustible products (metal powders) and combusive products (nitrates, chlorates,...).



Photos : R. D.

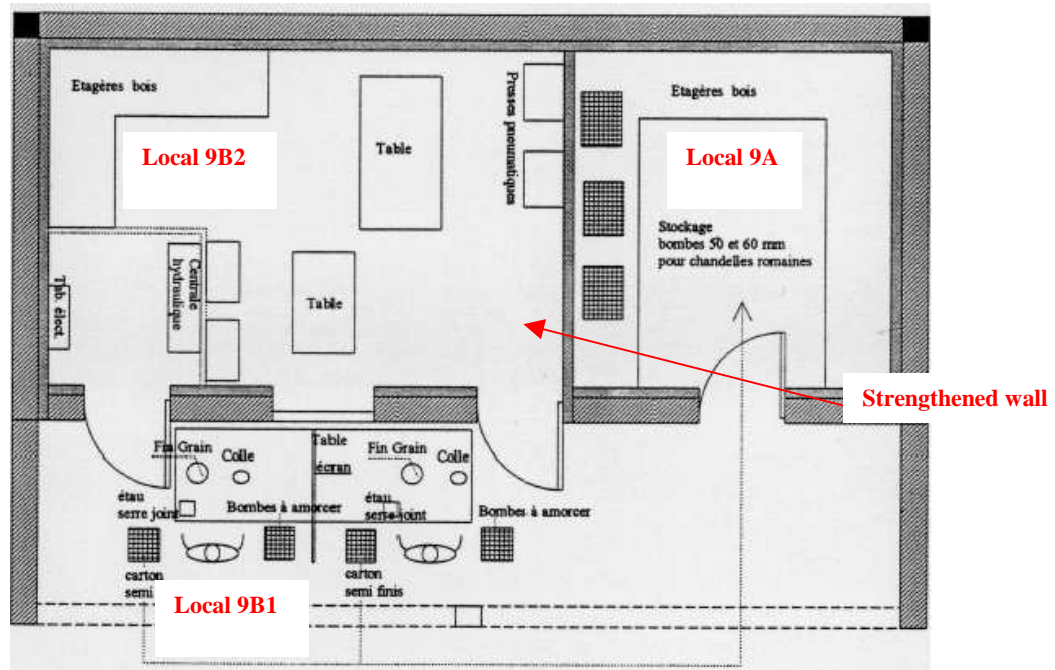


The pyrotechnic products manufactured on site include:

- ✓ stars, the main components of fireworks designed to produce light effects;
- ✓ light-effect shells, composed of a plastic shell in which the stars and the bursting powder are located;
- ✓ acoustic-effect shells where the stars are replaced by a pyrotechnic composition that produces the expected effect;
- ✓ candles which consist of cardboard tubes of various diameters. The shells and lifting charges are stacked successively inside the candles;
- ✓ Bengal lights, jets.

The workshop (building 9), involved in the accident, was dedicated to the manufacture of candles. It contained two workstations and a storage facility. Three consequential activities are performed:

- ✓ the shell assembly area, under the building's awning (facility 9B1). The operation consists in manually filling the lower part of the plastic shell with a bursting and star charge, and then to bond it with the upper part and arm the shell formed;
- ✓ intermediate storage of these products in storeroom 9A. The shells are stored in plastic boxes stacked on 5 levels on the wall separating this area and facility 9B2;
- ✓ the shells are loaded into the candles in facility 9B2. This operation consists in using a low-power hydraulic press to insert a series of armed shells and cups filled with powders into a cardboard tube with a closed base. The composition of these powders ensures the ejection of the shell from the tube.



The authorisation to operate this building prohibits the simultaneous shell assembly and candle loading operations. The shell storage facility was authorised to contain a maximum of 300 kg of active ingredients, characterised as non-detonating products (closed and armed shells). The maximum capacity of the two assembly and loading workshops was 5 and 2 kg of detonating products, respectively, owing to the handling of the powder.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident

On June 1st, 2004 at 11.20 am, a series of explosions rocked building No. 9.

Two people were working in the building at the time of the accident. According to the manager, the workers had begun assembling 60 mm dia. shells under the building's awning area (9B1) in order to make a few candles.

On the day of the accident, witnesses reported that the accident took place in 2 phases. An initial explosion occurred first, followed immediately by a second, more violent explosion which generated thick white smoke.

The consequences

Two employees were killed in the accident. Their extensively mutilated bodies were found 20 and 25 m from the epicentre of the explosion.

An employee who was in a building less than 20 m from building 9 at the time of the accident was very lightly injured even though the building was practically destroyed.

A second employee was also hospitalised for less than 24 hours for auditory problems.

Building 9 was completely destroyed. All of the walls are blown down to floor level, including the 40 cm wall anchored into the ground which had separated the 2 rooms of building 9. In the shell storeroom (room 9A), there was a crater measuring 3 m x 1.5 m and more than 50 cm deep, near the outside wall.

The explosion caused significant damage to the neighbouring buildings due to overpressure and projections. Fourteen buildings were partially or totally destroyed (structure and roof), the roofs of three additional building were damaged and the window and doors of six other buildings significantly damaged.

No domino effect was observed in the other shops or pyrotechnic stores. Only the plastic sheeting used to cover a greenhouse was partially burned owing to the stars that were launched onto it. This installation is located more than 70 m from building 9.



Photo : R. D.



Photos : R. D.

Debris was spread into four zones around building 9, in an elliptical shape. Each of the "pedals", which begin at the building's four walls, had an average length of 50 m. However, wall and roof debris was found up to 160 m away from the building.



Photo : R. D.

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.

Dangerous materials released		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input 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 type="checkbox"/>	<input type="checkbox"/>	<input 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 available at the following address: <http://www.aria.ecologie.gouv.fr>.

By default, parameter Q1 is rated 1 as the quantity of pyrotechnic products involved is unknown. Index Q2 is rated 1, as the equivalent quantity of TNT was estimated from 15 to 30 kg. The overall "dangerous materials released" rating is thus 1.

Two parameters are involved in determining the level of the "Human and social consequences" rating: H3 and H5.

- The parameter H3 reaches level 3: 2 employees killed (H3 between 2 and 5 deaths).
- The parameter H5 reaches level 1: 2 employees seriously injured (H5 between 1 and 5 injured).

As a result, the overall "Human and social consequences" rating is 3.

ORIGIN, CAUSES, EFFECTS AND CIRCUMSTANCES OF THE ACCIDENT

Several inquiries into this accident are currently on going :

- a judicial inquiry (the judiciary police are being assisted by the police forensic laboratory of Toulouse);
- an administrative inquiry.

The effect of the explosion of building 9 is rather surprising. The blast exhibited a detonation phenomenon although owing to the products present in the storeroom (where detonation took place) one would have expected a rapid and very intense burning without a significant blast effect, owing to the classification "1.3" of these products as defined by current regulations governing pyrotechnic materials.

The effect zones determined by the operator in the initial danger study did not exceed 20 m for the lethal effects and 38 m for the irreversible effect zones.

Owing to the consequences of the accident, an investigating bureau concluded that the detonation was equal to 15 to 30 kg of TNT. The shock wave recalculated on the basis of this hypothesis would give the radius maximum lethal effect and irreversible effects in the order of 40 m and 70 m, respectively.

Considering the information gathered in the field, it is possible that one of the two individuals, or even both of them, were inside the candle loading facility (9B2).

It can also be considered that this operation was conducted simultaneously with the shell manufacturing operation (although this configuration was prohibited).

Hypotheses about the circumstances

The existence of a crater inside the storage facility would prove that a significant quantity of products had detonated. The investigations took three possible causes into consideration:

- ✓ The risk presented by the products habitually stored in this area had been poorly evaluated (a detonation risk was not retained). In the trade, it is a recognized fact that the stars and small-diameter shells are classified as non-detonating products. As these products are not marketed "as-is", the operator did not submit these products to a certified organisation for classification testing. However, the "bulk" storage method and confined room may have played a role in the product's detonating behaviour. The question remains concerning the origin of the ignition;

✓ The products stocked may have been violently agressed and the energy absorbed may have lead to the detonating behaviour. In this hypothesis, the origin of the aggression may have been an initial accident in one of the two adjacent workstations (9B1 and 9B2), and relayed to the storeroom (9A) through a relay mechanism. However, close examination of the concrete slab of these two facilities (9B1 and 9B2) showed no sign of explosion (no impact, no fragmentation of the concrete or burn marks). As far as the relay effect is concerned, it should be noted that, in light of the projectiles found and the testimonies collected, at the time of the accident the door of the storeroom had remained opened (although prohibited by the safety procedure) and an industrial truck may have been placed near the door. The latter could have directed projectiles from the first explosion toward the facility. Pieces of the truck were found 150 m from the building in the direction of building 9A's access door.

✓ There may have been unauthorised detonating product inside the facility and which caused the shells to detonate after catching fire. Building 9's incoming/outgoing log was examined. The log does not indicate that the storage capacity was exceeded or the presence of products other than the 50 and 60 mm shells. The analysis of debris found in the bottom of the crater may possibly give an indication as to the nature of the pyrotechnic composition that detonated.

Hypotheses on the initiator

The origin of the initial ignition as well as its location still remains unknown. The first explosion at one of the workstations had left a mark on the concrete. A problem that occurred directly in the storeroom may be possible in case of incorrect handling. This second possibility cannot be confirmed by the position of the victims' bodies.

ACTIONS TAKEN

Upon the recommendations of the inspection authorities of classified facilities, the prefect issued an emergency order requiring:

- ✓ firework production to stop as re-commissioning the site will be subject to a new approval procedure
- ✓ All workshops manufacturing residual pyrotechnic products to be evacuated;
- ✓ all storage buildings to be refurbished such that they can store the facility's pyrotechnic products in acceptable conditions and within the storage limits;
- ✓ all intermediates to be stored in a third storage building;
- ✓ separate storage sites for commercial products and intermediates;
- ✓ all pyrotechnic products to be evacuated from other storage buildings;
- ✓ Constant surveillance of site;
- ✓ Final disposal of all intermediates whose behaviour is doubtful in case of activation.

Since the accident, the operator empties his stock of end products on the occasion of the summer 2004 firework season.

The elimination of intermediates that cannot be marketed was finalised by their destruction on the planned area located in the site and in compliance with all applicable rules.

The future of the site is being decided. A new operator wanted to take over the site under the existing approval conditions, namely ban on manufacturing products and limitation on storing products in the three authorised buildings.

LESSONS LEARNED

At this stage of the inquiries, feedback elements are essentially organisational in nature:

- ✓ characterise the risks associated with the products as best as possible (according to the storage and transport configuration), with special attention given to the intermediate products. As operators of small installations experience difficulties in classifying their products by standardised tests, better application of the standard rules must be sought as a minimum;

- ✓ respect the foreseen and posted safety rules. Vigilance on this point tends to drop over time and during activity peaks;
- ✓ maintain strict management of the operating conditions and the quantities of dangerous products present in the storage and manufacturing units.

These basic rules are already included in the regulations dealing with this activity.

Technically speaking, although without knowing the exact origin of the accident, several aggravating factors were raised:

- ✓ the bulk storage of shells and candles in crates, which generate a "confinement" of these products, most certainly contributed to a shift to a detonation configuration;
- ✓ the fact that the stored shells were armed may have lead to massive ignition through friction. Arming consists in bonding a layer of power onto the outside of the shells. This is to allow the flame to propagate from one shell to another inside the candles;
- ✓ the proximity of the storeroom for these products to the two fabrication shops tends to introduce a domino effect range that may be poorly controlled.

A spot inspection of 12 establishments was initiated 3 weeks after the accident in the Aquitaine region with mixed results. Administrative and penal actions were launched against 5 establishments. Complementary actions were also conducted in connection with other partners:

- ✓ Labour Inspectorate, given its involvement in the respect of texts regulating the activity;
- ✓ the mayors of the communities in the region who organise fireworks displays each year. The regulatory requirements associated with the temporary storage of fireworks near firing locations should also be reminded as well as their legal liability implicated by this operation;
- ✓ the administrative department responsible for the prevention of fraud for an establishment that has operated a fireworks manufacturing activity, without authorisation and for many years, and which has significantly exceeded the limit of its facilities;
- ✓ the police authorities to find the "hidden" storage location of a company being inspected, at the head office of which it had reported the absence of pyrotechnic products.

This operation determined that the last two fireworks manufacturers in the region did not operate in the same manner. The shells were prepared whenever they needed candles (thus no intermediate storage), or stored in a remote location and not armed.