Detonation of an explosive during compression

June 8, 2005

Bourges [18]

France

Pyrotechnics / Explosives
Detonation
Explosive compression
Safety distances

THE FACILITIES INVOLVED

The site:

The site's pyrotechnics activities are primarily connected with the Design and Testing sectors, which encompass input from a number of distinct professional sources, including: systems analysis, pyrotechnics, metal and composite materials, ballistics, and onboard electronics.

The centre proposes its research and development specialities in the sectors of complex systems design that combine mechanics, hydraulics and electronics, with metal material characterisation, chemistry, simulation and modelling, customised testing protocols and logistical support.

Facility operations are governed by *SEVESO II* regulations for the storage of powders and explosive products.

The unit involved:

The building is located some 300 metres from the access road and 400 metres from the bypass highway serving the neighbouring town.

It housed pyrotechnics activities featuring the compression of explosive materials through use of two presses (medium- and large-capacity) capable of operating over a range of temperatures. These activities were divided across several physically separated premises.

A total of eight other pyrotechnics buildings were located within a radius of 50 metres, separated by distances of 10, 20, 30, 35, 39, 42 and 46 m, respectively.

The explosion occurred at the level of the large-capacity press. This room was set up in the building basement. The roof of the compression area was composed of an 0.80-m reinforced concrete slab covered with earth. The exterior walls were between 0.80 and 1.50 metres thick. Thickness of the wall separating the compression room from the associated control room was 2.50 metres.

In the compression room, a lightweight, explosion-venting partition wall was built, leading to a 9.50-m high expansion conduit backed against the earth discharging into the open air. This chimney set-up made it possible to channel the pressure surge effect from an explosion and direct it upwards.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

A 5.6-kg explosive compression was initiated in the building on the large-capacity press. A fibre drum containing 14 kg of explosives was also present near a weighing station within the same room. Two technicians working in the control room were supervising the procedure by video camera.

Another technician was assigned to a workstation in an adjacent building 10 metres away.

Around 9:25 am, a detonation occurred at the level of the tooling station for the large-capacity press. The personnel, protected by the configuration of these premises, were not hurt by either the excess pressure wave or flying debris; they evacuated the building via an emergency ladder and gathered in an adjoining building, from where they could notify safety staff.

The response team then alerted the site's top managers, who appeared on the accident scene to meet with the three technicians involved and assess their health. In a state of psychological shock, the technicians were admitted to the site's infirmary.

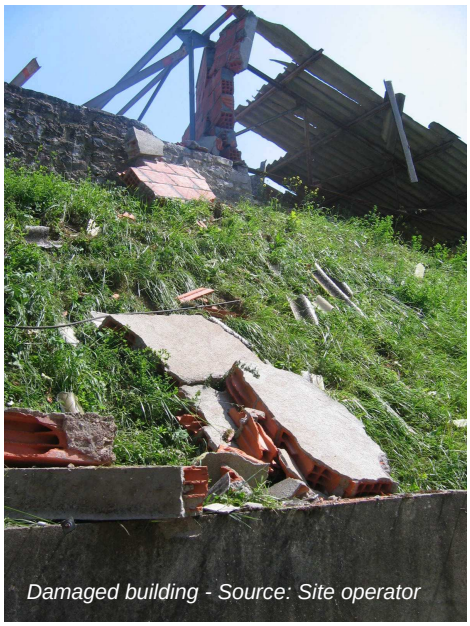
At 9:30 am, it was decided to call the external response unit and launch the internal emergency plan (POI). The building used as the pyrotechnic chamber for this test was evacuated and the personnel assembled; a roll call revealed no one absent.

The DRIRE regional oversight agency was notified of the accident at 9:45 am by the individual responsible for external relations, as stipulated by POI response measures. The Prefecture's offices were also informed of the incident.

The external response team arrived around 9:50 am and set up operations in the plan's designated control room. A status update regarding the presence of explosive products was produced from information submitted by the unit's technical staff and managers.

An initial reconnaissance step was undertaken and revealed that a small amount of smoke was being released through an opening in the expansion conduit of the room where the explosion had occurred, thus indicating the existence of a combustion. Given the possible presence of unburned explosive, fire-fighters took up positions outside the building (beyond the Z2 detonation zone), protecting themselves behind a wall and placing a nozzle in a battery configuration to spray water through the opening, in an attempt to snuff out the fire.

By 10:50 am, smoke could no longer be detected. For safety reasons, the officer overseeing the emergency intervention decided as a precautionary measure to flood the room with foam; a high-expansion emulsifier, supplied ahead of time, was set on the slope at the edge of the expansion conduit opening at 11 am. An initial filling was entirely completed; 20 minutes later, part of the foam fell and an additional filling was required. This operation lasted until 1 pm.



Damaged building - Source: Site operator

The decision was made not to enter the damaged building until the following morning and to withdraw the fire-fighting equipment. This POI emergency plan was lifted at 1:30 pm.

Consequences of the accident:

The detonation caused both a pressure surge and the projection of debris, which could be dissipated by the room's expansion conduit.

Two technicians inside the building were protected; the accident produced no victims.

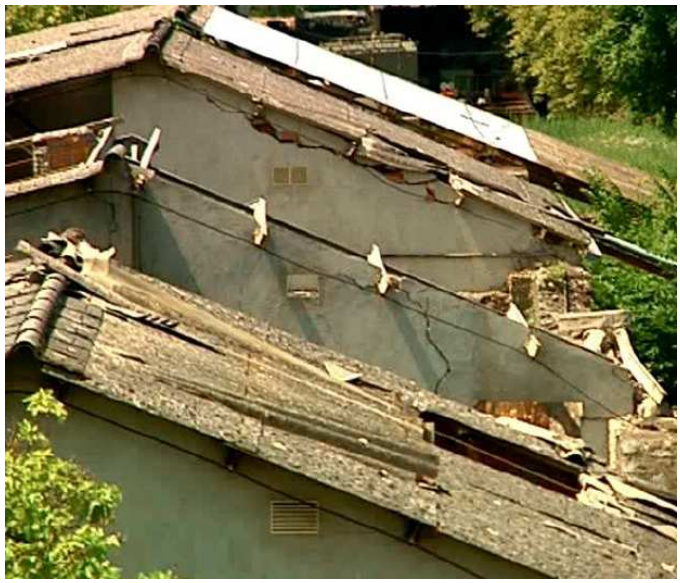
The roofs on the exposed building as well as on the closest neighbouring building sustained damage due to the effects of the blast and projections, with broken window panes observed on some of the buildings composing the enclosure.

A fragment of translucent polycarbonate (0.30 m x 0.40 m) was found 65 metres from the scene of the explosion; it might have been part of the lightweight, explosion-venting partition wall between the press room and the expansion conduit.

The impact zones corresponding to the explosion of the quantities present (20 kg) extended roughly 20 m for the Z2[1] zone and 120 m for Z5[2]. No effect was recorded outside the site boundary.

Press room damaged by the explosion (Source: site operator)

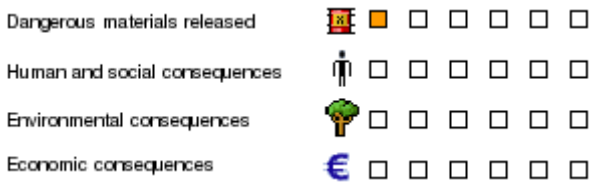
[1] Corresponds to the very serious hazard zone (see the modified administrative order issued on April 20, 2007 establishing the rules relative to risk evaluation and accident prevention in pyrotechnics facilities).
[2] Corresponds to the zone of indirect effects caused by broken window panes.



Destroyed roof on the premises (Source: site operator)

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

Two parameters were involved in determining the rating level of the "Hazardous materials released" index: Q1 and Q2.

- 20 kg of explosives represent less than 0.1% of the corresponding Seveso tier (50 tonnes - unclassified explosive substances within Division 1.4, as per the U.N.'s ADR convention), which is equivalent to Level 1 of the "quantities of hazardous materials" index according to parameter Q1;
- Since the effects of this explosion had not been characterized and the assessment of projection distances for broken window glass was approximately 100 m, parameter Q2 has been rated at a level of 1.

As a result of these parameter values, the overall level of the "Hazardous materials released" index reached 1.

Given that no injuries were reported, the "Human and social consequences" index was assigned a 0 value.

Likewise, the absence of environmental impacts resulted in a 0 rating for the "Environmental consequences" parameter.

Since no information is available on economic consequences, the "Economic consequences" index has not been rated.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The causes of this explosion have not been identified. When questioned, one of the two technicians present in the control room at the time of the accident mentioned noting nothing out of the ordinary during the compression cycle prior to detonation.

Upon completion of the analysis, several causes still appear to be plausible (listed here from most to least probable):

- an adiabatic compression of air within the powdery explosive,
- electrostatic discharge,
- the presence of a foreign body inside the explosive.

ACTIONS TAKEN

Immediately thereafter, the facility operator began making periodic rounds at the perimeter of the enclosure and around the damaged building, in order to verify in particular the absence of ignition.

A complete inventory of the damages sustained by the other buildings was drawn up. Before entering the premises to perform their inspection, fire-fighters surveyed the scene of the accident using a thermal imaging camera and laser sighting device to detect any eventual hot spots.

Site personnel were assembled the very same day; the company's committee for hygiene, safety and working conditions and the Works Council met a few days thereafter to issue a statement on the circumstances of the accident.

Subsequent to the accident, a film was produced that re-enacted the sequence of events and effects (i.e. types of damage) arising within the various impact zones; this film was used for in-house instructional purposes in the training of new hires.

LESSONS LEARNT

The building's layout and the organised separation of premises played an effective role by protecting the technicians inside the building. The isolation distances with respect to adjacent installations, as set forth in the regulations on pyrotechnics activities, also proved effective as regards both the personnel in adjoining facilities and any eventual domino effects.

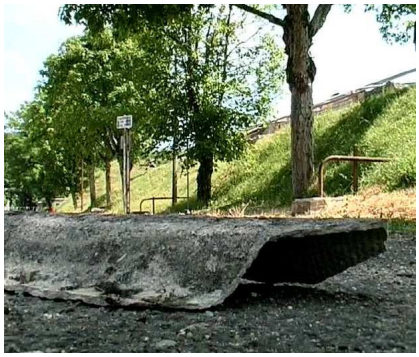
Communication among the various POI participants was extremely smooth and internal emergency procedures were very well coordinated.

The presence of the drum of explosives at the weighing station, in the same room as the press, hindered the efforts of safety teams due to: uncertainty over the condition of the drum and its contents after the explosion, potentially remaining quantities, the likelihood of detonation or ignition subsequent to the accident, possible risks for fire-fighters, and the appropriate safety perimeter to be implemented.

In this respect, the efficiency of the flooding with foam during rescue operations can be questioned with regards to the risks. The extinguishing agents were efficient on combustible materials inside the room, but not on the explosive substance itself. Indeed, since explosives contains oxygen within their molecules, they are permanently active… Evacuation, area protection and waiting are often the only possible interventions.

With the objective of restoring operations at the cluster neighbouring the accident site, the operator proceeded by:

- separating the weighing station (the 14-kg drum, positioned close to the press, further complicated the accident) from the compression station, thus decreasing the mass capable of reacting;
- prohibiting the resumption of compression operations on products with similar masses.



Debris found in Z4 (Source: site operator)