Accident during an "Emergency Plan" drill

11 June 2013

Tilloy-Lez-Cambrai (Nord)

France

Automatic extinction
Emergency plan
First response
Evacuation
Human factor

THE FACILITIES INVOLVED

The site:

The plant has a workforce of some 200 people (see Fig.1). Given its activities, it is subject to environmental permit. The products manufactured at the Tilloy-lès-Cambrai site are as follows:

- Hollow glass microspheres for industry and the oil sector
- Glass beads (solid backlit glass microbeads)
- Retro-reflective adhesive tape adapted to ground markings for the traffic signal market
- Industrial adhesives (glues, sealants, coatings).

Figure 1 : Aerial view of the plant (source : Fabrice Loze, ARR)

The involved unit:

This accident occurred in a building housing the Adhesives unit (Fig. 2); the building contained a total of 7 rooms. Mixing workshop room no. 6 was laid out with 2 exit doors: a primary door accessing the main building hallway and featuring a fire proof door with a controlled closing mechanism; and an emergency door leading outside the building and fitted with an anti-panic closing system.

Each room was equipped with a fire extinction system relying on CO_2 injection that operated as follows:

- presence of 2 fire detection cells: thermal and optical (flame detector);
- one of these means of detection triggered the personnel evacuation siren;
- the two detection sources (if simultaneous confirmation of both alarms) controlled automatic CO_2 injection activation in the targeted room, after an 18 to 20 seconds self-timer delay, allowing the time necessary for employees present to evacuate;
- at the end of the self-timer delay, the fire door of the particular room closed automatically.

CO_2 was injected into the rooms by saturation thanks to a reserve composed of 76 kg bottles located outside the building. In room No. 6, the system comprised 8 injection nozzles positioned at the top and capable of being activated in either automatic or manual mode (with a manual CO_2 trigger placed near the emergency doors).

To complete this fire protection system, the building was also protected by a sprinkler type installation (Fig. 2).

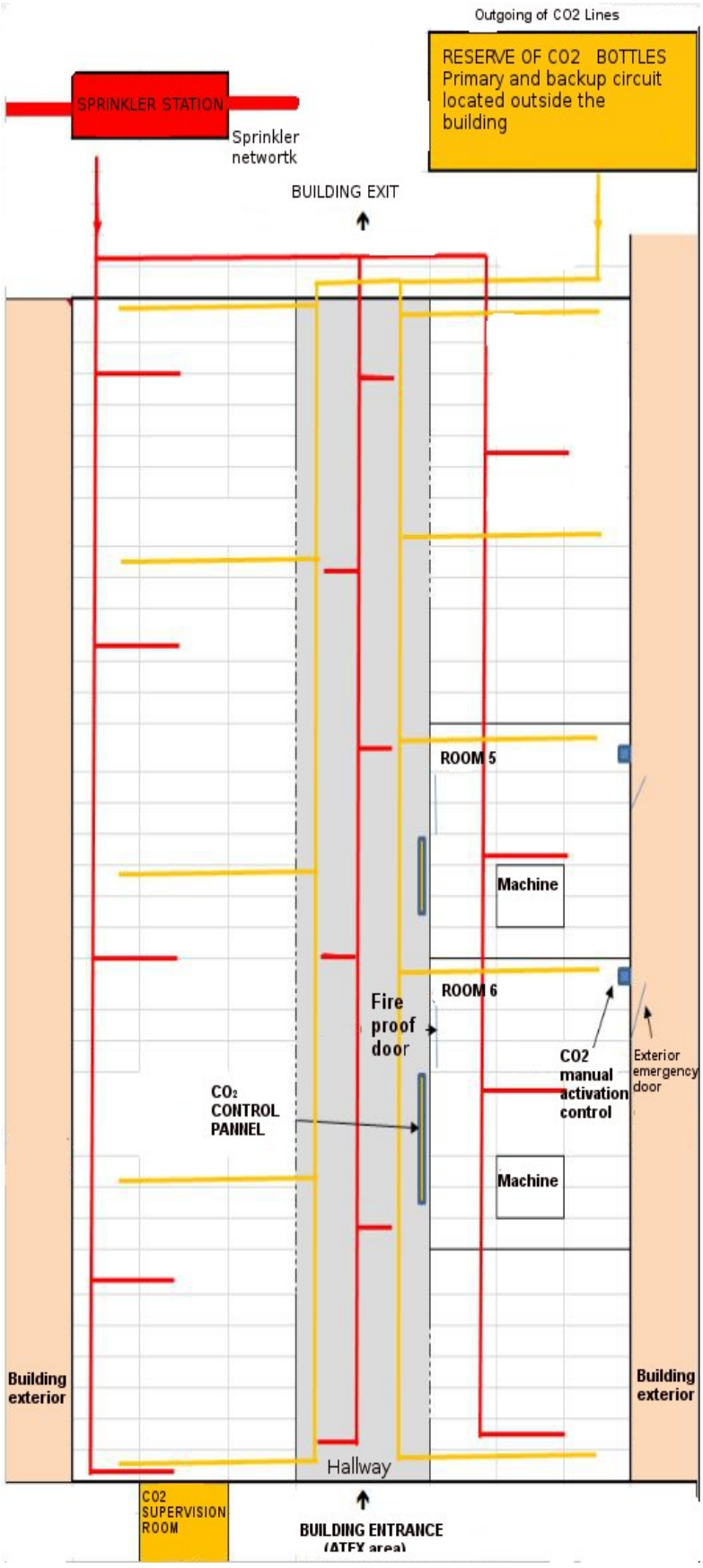

Figure 2: Fire protection devices inside the adhesive workshop building (source: DREAL NPDC)

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

The drill was intended to test the site's emergency plan. Several observers not affiliated with the site were present on this particular day: the local government representative, representatives of an expert fire prevention body (CNPP), police officers, and fire-fighters. The drill was scheduled to start at 9:30 am and act the following scenario:

- Simulated exothermic reaction with smoke candles placed in Room 6;
- Closure of the primary door to Room 6;
- Activation of the CO_2 injection and saturation of Room 6 with CO_2;
- Reconnaissance by 2 responders (a maintenance technician and a subcontracted security agent);
- Ventilation of Room 6 to extract the CO_2;
- Positioning of a dummy victim (another security agent who had participated in preparing this drill);
- Evacuation of the dummy victim by the 2 responders working as a pair.

The Head of "Safety & Security", responsible for the site's fire protection, supervised the emergency response operations in accordance with his "response" function as stipulated in the emergency plan. Both responders were experienced (over 10 years of seniority each at the site) and trained in the site's Emergency Plan (EP) procedure. They were wearing emergency gear, namely a self-breathing apparatus.

An employee with the specialised subcontractor in charge of maintaining the CO_2 protection installation was present for the drill and assigned the mission of:

- Disconnecting the CO_2 extinction of the building's other rooms before initiating the drill;
- Choosing, from among the bottles supplying CO_2 to these rooms, those bottles to be installed for subsequent retesting instead of the recent bottles supplying Room 6 (in the aim of optimising consumables).

His firm was informed ahead of time that the drill was scheduled to begin at 9:30 am.

In reality, the drill did not take place as planned and instead proceeded by the following accidental sequence:

At the outset of the drill, everything progressed according to plan. The Head of "Safety & Security" installed smoke candles in Room 6 to simulate an accidental exothermic reaction occurring during the process. After evacuating the personnel present in the room, the fire door was closed.

The subcontractor's employee had not finished interchanging the CO_2 bottles supplying each of the adhesive building's rooms. The "Safety & Security" manager had not been informed of this delay and continued the drill by activating the manual "general evacuation" alarm at the building entrance. Upon hearing the siren, the site's workforce collected at the various designated gathering points.

The two responders (designated emergency plan intervention duo) equipped with their self-breathing apparatuses stood opposite the fire door to Room 6 in the building hallway. The "Safety & Security" manager informed them by radio of the place where the alarm would be sounded to trigger the general evacuation. The 2 agents then waited for instructions from this manager, who was now assuming the role of response coordinator. To simulate a search for victims, he asked these agents to wear their self-breathing mask and prepare to enter Room 6 once the CO_2 injection was over.

An **initial deviation** occurred. It was actually necessary to wait 20 minutes before the subcontracted employee confirmed to the manager that the task of preparing bottles for the "CO_2 blast" had been completed. This unexpected delay seriously upset the manager, who in the meantime had to go back and forth inside the building to monitor the blast preparation. Moreover, the external observers - including a high-ranking official - were anxiously awaiting the rest of the drill. From his vantage point, the security agent playing the dummy victim's role interpreted this delay as a cancellation of the CO_2 blast. It was at this point that the **second deviation** arose: unknown to the other drill participants, this agent entered Room 6 without having received any instruction to do so.

A few minutes later, the manager returned towards the exterior emergency door to Room 6, where two observers were waiting for him. In his haste, he manually triggered the CO_2 injection: the warning siren rang for 20 seconds in the room, then the injection procedure was initiated. This decision constituted a **third deviation** since the planned scenario called for the security agent - in the subsequent role of dummy victim - to activate the injection and not the manager.

A **fourth deviation** simultaneously appeared when, inside Room 6, the dummy victim did not react to the siren announcing activation of the CO_2 injection. In compliance with instructions given to employees, the victim should have immediately left the room. Instead, he remained standing underneath the injection nozzles as the CO_2 spread. The victim quickly fell to the ground unconscious due to the anoxic atmosphere filling the room.

In seeing this turn of events through the window of the emergency door, the manager decided to rescue the victim by holding his breath. He took backward steps in dragging the inanimate body of the dummy victim towards the emergency door. Since visibility in the room was reduced subsequent to the injection and smoke candles, he fell into the pit on the platform lift used to load products into the mixer. During his fall, he instinctively inhaled and also lost consciousness. The two "real" victims of this drill were thus both close to the exterior emergency door to Room 6, yet were lying motionless on the floor. The two responders wearing self-breathing apparatuses, who were waiting in front of the room's primary door to evacuate the dummy victim, did not react due to a lack of visibility or instructions received by radio.

The two observers adjacent to the emergency door thus decided to rescue the victims and entered the room holding their breath, while the third observer notified the crisis unit. The drill was immediately halted and the emergency plan activated for the real accident that was unfolding. Employees present near the building hurriedly provided an initial oxygen relief to the two victims using self-breathing masks and then an oxygen bottle. The departmental rescue services, also present as an observer, assumed responsibility for the 2 victims and their rescuers, who had also been exposed to CO_2.

Consequences of this accident:

The consequences of this accident were solely human: 5 people (4 employees and 1 security agent working with a subcontracted firm) had to be treated subsequent to CO_2 exposure:

- 3 of them were admitted to the town of Cambrai Hospital and released at the beginning of the afternoon (2:30 pm).
- 2 others sustained more serious exposure and had to be transported by helicopter for treatment in a decompression chamber at the town of Lille Hospital. They were released at the beginning of the evening (8:20 pm).

This drill also revealed a series of technical defects on the CO_2 injection installation, yet these had no bearing on the accident:

- A leak on the CO_2 supply line at the level of a union connection. This leak was observed in the building hallway in the vicinity of Room 6.
- A malfunction on a CO_2 line check valve caused the tapping of 13 CO_2 bottles instead of the 9 intended for Room 6

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 available information, this accident can be characterised by the four following indices:

The parameters composing these indices and their rating methodology are available on the Web page: http://www.aria.developpement-durable.gouv.fr.

The "hazardous substances released" index was scored a "0" since no substance included on the Seveso Directive Appendix I list was actually released.

The "human and social consequences" index received a "2" rating due to the 5 individuals exposed to CO_2 and hospitalised for a period of less than 24 hours.

The "environmental consequences" index was not rated given the absence of any environmental impacts.

Lastly, the "economic consequences" index was assigned a "0" score as the result of no direct damage to any of the site's production or safety equipment.

THE ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Many investigations were conducted by the plant Committee for Hygiene, Safety and Working Conditions (CHSCT), and a causal tree analysis was carried out. Conclusions on the causes of this accident were as follows:

- The drill got under considerable anxiety due to:
  - the presence of a number of external officials, who were there specially for the occasion;
  - the delay in setting up the CO_2 bottles (for the blast) by the company specialised in CO_2 maintenance;
  - the extra time required to start the drill and assemble the crisis unit.
- Failure to follow the planned and validated scenario:
  - The staging of this drill was delayed due to the time required to set up the CO_2 bottles. This delay created some unplanned dead time between the general evacuation and triggering of the CO_2 injection;
  - During this idle period, the dummy victim entered Room 6 by the emergency door without first receiving the instruction to do so. The external observers did not see him enter. For his part, the "Safety & Security" manager was busy inside the CO_2 utility room located 30 m from Room 6;
  - Upon his return to the CO_2 room, this manager proceeded to manually activate the CO_2 injection, in the place of the security agent (in the role of dummy victim), in violation of the initial plan.
- The drill scenario was not precise enough. Moreover, it did not sufficiently detail the tasks to be carried out, at what specific times and by whom.
- Problems in perceiving the situation and/or establishing communication between drill participants:
  - The "dummy victim" thought that the CO_2 bottle blast had been cancelled. No instruction regarding the blast had actually been given to him for 20 minutes following the beginning of the drill, especially given that this victim was, according to the scenario, responsible for unleashing the blast;
  - Not imagining that the blast could still be on the program, the "dummy victim" paid no attention to the sound of the CO_2 siren or the injection pipe pressurisation alarm. This employee remained standing under the injection nozzle, despite being trained in CO_2 risks and possessing 10 years of experience as a security agent;
  - The "Safety & Security" manager was responsible for both organising the drill and overseeing its operations. If an unexpected event arose, he was incapable of seeing the big picture so as to analyse all consequences for the ongoing drill and adapt his response. Best practices in the area of on-site drills stipulate that organisers are to solely act as observers during the drill exercise.

ACTIONS TAKEN

Subsequent to this accident, a short-term action plan was immediately drawn up; it focused on verifying both the workshop atmosphere and CO_2 injection installations, for the purpose of resuming production (ventilation of the room and hallway, verification of safety servo-controls, etc.).

Next, the following actions were conducted:

- Production of a causal tree as of the following day, along with an associated action plan;
- Information feedback to authorities attending the drill (Environmental Agency, Labour Inspection, pension fund/workers' compensation insurer);
- Internal investigations in conjunction with the Health and Safety Technical Committee;
- Technical analysis with the firm specialised in maintaining the CO_2 injection installation, in order to confirm the 2 technical anomalies detected, and then rectifying them;
- Completion of a second verification and test of the entire installation during its various modes of operations (automatic, manual and idle);
- Introduction of a lockout mode (padlocked grating) on the console ordering the manual activation or shutdown of the CO_2 extinction system, as well as on both the primary and backup line boxes;
- Recall of CO_2-related risks during special CO_2 training sessions offered to personnel and when training new recruits;
- Modification to the security rounds (to include verifications of the manual CO_2 extinction control tables);
- Update of the procedure for manual activation or shutdown of the CO_2 extinction system;
- Review of the CO_2 protection services contract with the maintenance firm specialised in CO_2 injection: increased frequency of pipe inspections, replacement of check valves;
- Audit by the expert body of the CO_2 protection installation in the presence of the maintenance specialist;

- Emergency Plan update incorporating feedback experience from the accident: integration of each scenario identified into the plan, addition of the procedure overseeing the drill exercise.

LESSONS LEARNT

The main lessons drawn from this accident are the following:

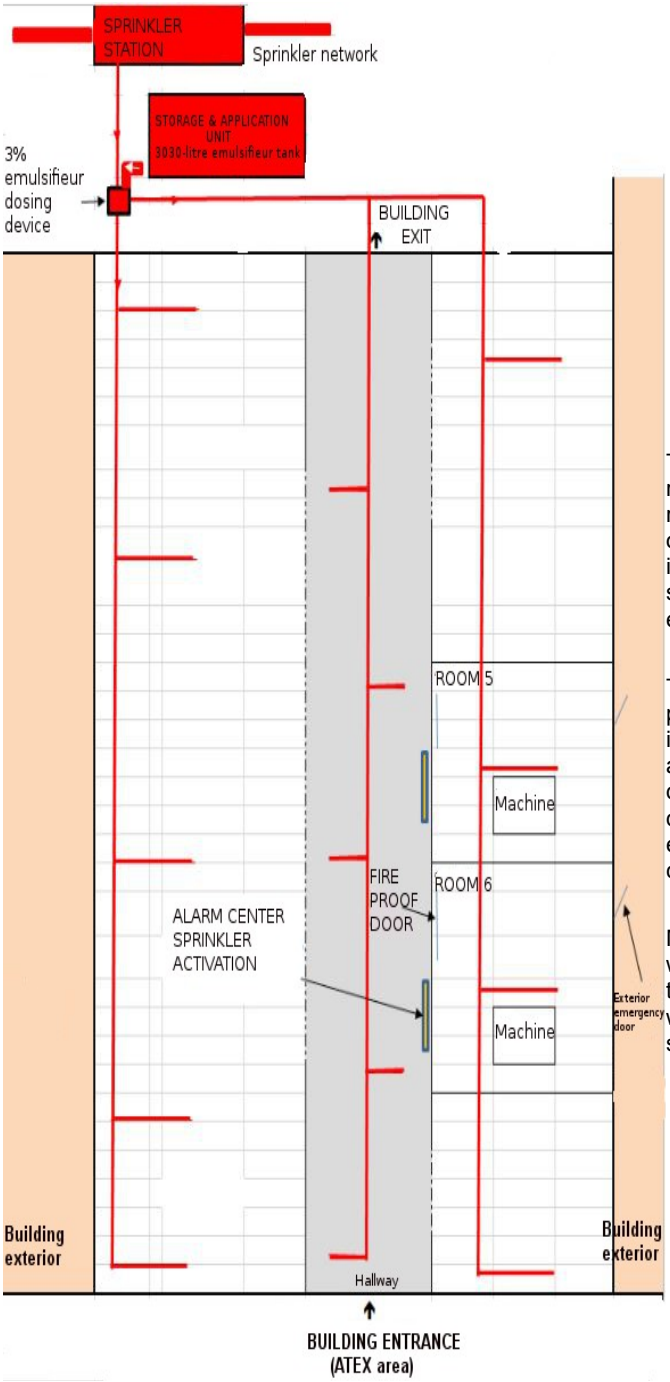

Figure 3 : New configuration of the fire protection systems deployed in the adhesive workshop building (source: DREAL NPDC)

- Every aspect of the planned and validated scenario for a safety drill must be respected. The scenario cannot be changed at the last minute. Only a formalised change and its validation by the Head of Emergency Response or Director of Internal Operations (for SEVESO-rated sites) can be authorised.
- The scenario must clearly indicate "who is controlling what for each step?" in order to guarantee that all risks are being effectively managed. This drill never should have started as long as all planned conditions had not been met.
- The Emergency Plan must contain the main scenarios anticipated (major risks) based on the safety report dedicated to site installations.

This accident led the facility operator to reflect on the relevance of his CO_2 protection installation. An audit, requested of the CNPP fire safety body, convinced the operator to change his fire protection strategy. CO_2 injection was replaced by a modification to the existing sprinkler system, with the addition of a 3030 litre emulsifier tank.

This decision was accepted by the site's insurer. The principal advantage of this new installation lies in improved personnel protection; it actually eliminates all risks of creating an anoxic atmosphere. Its disadvantage pertains to the risk of equipment deterioration following the presence of water and emulsifier should a fire ignite, thereby requiring deep cleaning for all such equipment.

Modification to the existing sprinkler system, coupled with the addition of emulsifier, was performed during the 1st quarter 2015. Each room in the adhesive workshop is now equipped with the following detection system (Fig. 3):

- 2 fire detection cells: one thermal the other optical;
- One or the other of these 2 detection devices controls the overall site's personnel evacuation siren, with an alarm relay to the safety unit;
- Both detections (provided confirmation of the two alarms) are able to trigger: the safety servo-controls (energy outage), the room's pneumatic and electrical siren, and the alarm relay to the safety unit.

This new design of fire protection system operations (replacement of the CO_2 installation by a "sprinkler + emulsifier" device) is also being shared at the Group level and has triggered modification projects at other sites.