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Activities around upper-tier SEVESO sites: How to protect against technological risk?

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In France, two years after the catastrophic industrial accident of Toulouse, a new law was introduced on July 30, 2003 which created the Technological Risk Prevention Plan (PPRT in French, standing for *Plan de Prévention des Risques Technologiques*). The aim of the PPRT is to protect people by action on the existing urbanization and by controlling the future land-use planning in the vicinity of the existing upper-tier SEVESO establishments.

Each PPRT imposes rules of land-use, use and exploitation of buildings and activities, in a differentiated zoning according to the potential hazards: red zones (dark then clear) in the immediate proximity of the dangerous installations, and blue zones (dark then clean) further away from the danger.

This article presents a methodology to help the activities concerned by a PPRT (more particularly those located in the blue zoning) to implement and optimize their protection. The approach follows 5 main stages:

- Identification of the hazards affecting the activity
- Analysis of the vulnerability of buildings (overpressure, thermal and toxic effects) and the vulnerability of staff working indoors or outdoors
- Analysis of the dynamics of dangerous phenomena (time available for people to be safe)
- Study and choice of measures
These measures may include informing and training staff and visitors, setting up an organization to react during an accident (receive and broadcast the alert, joint a confinement room or a refuge area, evacuate...) or carrying out protection works (reinforcement of buildings).
- Implementation of selected measures and monitoring

1. Introduction

Established in France in 2003, the Technological Risk Prevention Plan (PPRT) is a tool for managing land-use planning in the vicinity of upper-tier SEVESO sites.

The PPRT consists in assessing and prioritising the risk level associated with the SEVESO establishment on the impacted territory. These levels enable the definition of zones, each having its own land-use planning and construction rules.

There are two types of zones (see Figure 1):

- red zones (ban on new construction, expropriation / relinquishment...);
- blue zones (new construction possible depending on limitations on use or protection measures, reinforcement works for houses...).

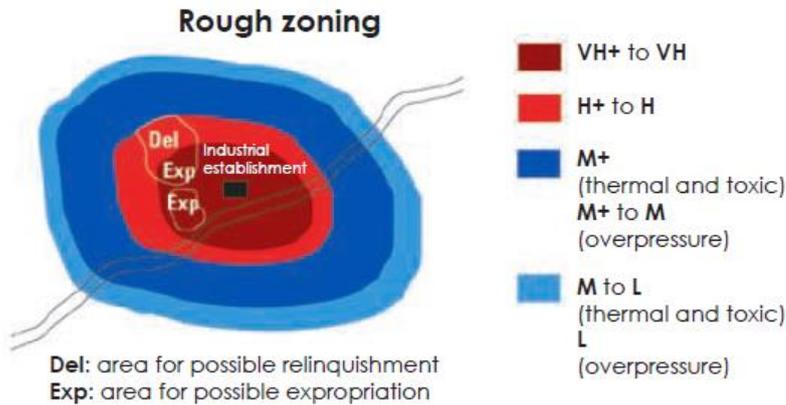


Figure 1: Rough zoning of the PPRT

For any kind and any size of activities (factory, office, shop, craftsmen company...) located in the hazardous areas, the PPRT provides:

- expropriation / relinquishment for those located in red zones, unless the activities propose alternative measures (technical and organizational measures) with a significant improvement in the safety of people;
- implementation of measures for the protection of employees (labour regulations) for those in blue zones.

The purpose of the method described in this paper is to give guidelines to the leaders of these activities for defining the measures to be taken (mainly for blue zones and, within certain limits, for red zones).

2. Description of the methodology

The proposed methodology for the integration of technological risks for activities located the surroundings of SEVESO sites follows a sequence in 5 steps, as detailed below:

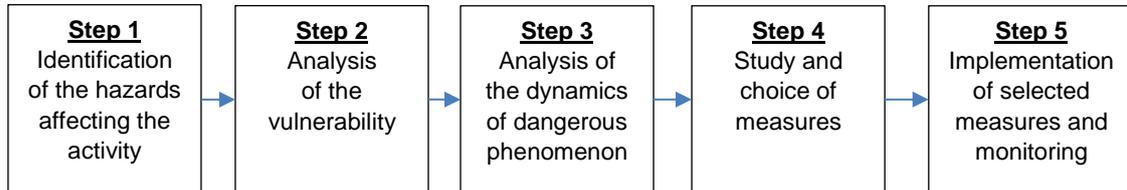


Figure 2: The 5 steps of the methodology for the integration of technological risks for activities located in the surroundings of SEVESO sites

2.1 Step 1: identification of the hazards affecting the activity

The objective of this step is to collect data relating to the dangerous phenomena impacting the activity near the SEVESO site, in particular:

- the accidental scenario (ruin of capacity, leak of piping...);
- the types of effects: toxic, thermal and overpressure;
- the nature of the effects: continuous or transient for thermal, shock wave or blast for overpressure;
- the level of intensity;
- the application time (for overpressure);
- the orientation of the faces of the buildings regarding the origin point of the studied dangerous phenomenon;
- the probability of occurrence.

2.2 Step 2: Analysis of the vulnerability

On the basis of the information collected in step 1, the aim is to determine the vulnerability of the buildings and the personnel of the activity to impacting hazardous phenomena.

To do this, the proposed methodology is to reason taking into account:

- the topography, the presence of obstacles (natural or anthropogenic) between the SEVESO sites and neighbouring activities;
- the vulnerability to accidental effects of the activities buildings;
- the vulnerability of staff working inside or outside of these buildings.

2.3 Step 3: Analysis of the dynamics of dangerous phenomena

The manager of the enterprise, which faces several risks (occupational risks, technological risks...) has to choose the dangerous phenomena for which it's necessary to protect. His choice could depend on a set of data such as, for example, the preponderance of occupational risks, the occurrence probability of various technological effects coming from outside, the human and financial resources...

Using Table 1, it's possible to classify the dangerous phenomena in one of the following 3 categories:

- "Immediate": no precursor incident that allows to detect the occurrence of the dangerous phenomenon;
- "Temporized": several minutes between the first detectable event (in connection with the possibility of an early warning) and the arrival of the effects of the dangerous phenomenon, giving the time of securing the people present in the activity;
- "Delayed": several tens of minutes between the first detectable event and the arrival of the effects of the dangerous phenomenon, giving the time of securing the people present in the activity.

Table 1: Determination of the dynamics for dangerous phenomena

Dynamics of dangerous phenomena	Continuous thermal effects	Transient thermal effects	Toxic effects	Overpressure effects
Immediate	Jet fire (1)	Flash fire (U)VCE BLEVE	Toxic cloud (5)	(U)VCE Tank burst (7) Solid explosion
Temporized	Pool fire Solid fire (3) Jet fire (2)		Toxic cloud (6)	
Delayed	Solid fire (4)	Tank pressurization Boil-over		Tank pressurization

(1) Building directly impacted by the jet fire

(2) Building not directly impacted by the jet fire, but only subject to thermal radiation (< 5 kW/m²) and with a distance to escape compatible with the irreversible effects thermal dose for people outside

(3) Speed of fire propagation is relatively fast

(4) Speed of the fire propagation is relatively slow (several tens of minutes in the case of a warehouse)

(5) Case of capacity rupture and without possibility of early warning (before the rupture) or leak with effects distances calculated considering a few minutes duration exposure

(6) For the cases of capacity rupture with possibility of early warning (before the rupture), the fed leaks, the evaporation of liquid pool and fire fumes, with effects distances calculated considering a long duration exposure

(7) In most cases and without possibility of early warning (before the rupture)

2.4 Step 4: Study and choice of measures

The possible measures are given in Figure 3 on next page.

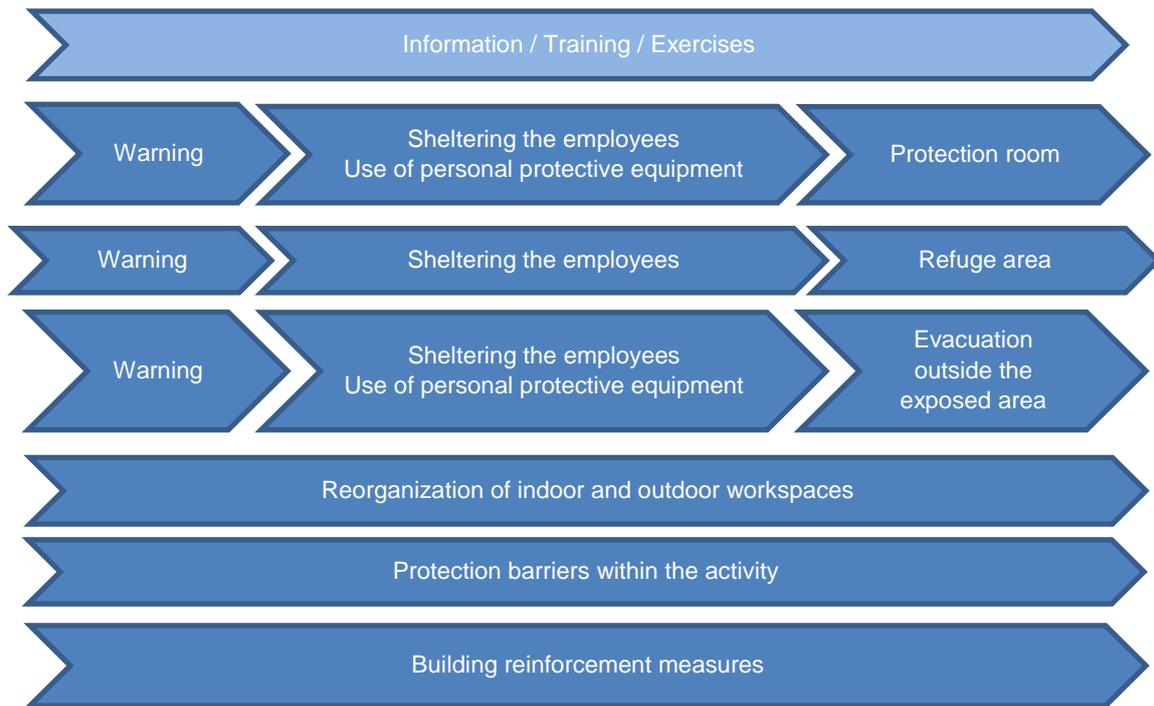


Figure 3: List of possible measures for the protection of people in activities near the SEVESO sites

Each measure is then described more precisely.

- Information / Training / Exercises
It's very important to inform the visitors, all the people likely to be present in the installations concerning the instructions in case of alert of technological risks, to train the personnel.
- Warning
The principle of the alert is to ensure a transmission of information between SEVESO establishments and neighbouring activities, in order to secure the people and to better adapt the behaviour to take. This transmission must be as early as possible, efficient, clear and reliable.
- People moving to a protection room, a refuge area or evacuation outside the exposed area
After receiving the warning, the people present in the activity are protected from danger by:
 - evacuating from the exposed area, before the occurrence of the dangerous phenomenon;
 - going to a sufficiently robust protection room to ensure the safety of the persons until the end of the dangerous phenomenon or until a possible evacuation decided by the emergency services (duration of 2 hours minimum);
 - leaving the buildings by the non-exposed side and sheltering in a refuge area outside, not subject to the aggressor effects.
- Reorganization of indoor and outdoor workspaces
It could also be envisaged to modify the geographical location of indoor and outdoor workspaces in order to limit the level of exposure to technological risks. For example, technical rooms with non-permanent human presence could be located on the exposed faces of buildings, offices with permanent human occupation on the opposite unexposed faces of buildings.
- Protection barriers within the activity
Protection barriers (passives barriers such as wall...) are possible within the activity to protect people to various effects likely to come from the neighboring SEVESO establishment.

- Building reinforcement measures
Solutions are proposed to increase the resistance of buildings, for example, insulation of walls and / or roof for thermal effects, films on glass surfaces, reinforcement of different parts of the envelope (walls, roof), of the supporting structure of building, reinforcement of metal structures...

The selection of the most appropriate measure(s) is based on the dynamics of the dangerous phenomena (see step 3).

For “immediate” hazards, the technical measures are optimal. Nevertheless, it may be necessary to combine these measures with organizational measures (alert, personal protective equipment...).

For “temporized” dangerous phenomena, people can use the few minutes available to reach a protection room, a refuge area or evacuate. However, it may be appropriate to consider, in addition, physical protection measures.

In the case of “delayed” dangerous phenomena, the available time (several tens of minutes) is sufficient for organizational measures only (confinement in more distant protection rooms or evacuation outside the exposed area).

If the activity is impacted by several dangerous phenomena, the set of solutions chosen is to be consistent with the effects that may impact it, it’s necessary to have a single strategy for all the effects.

The following Table 2 relates the effects and dynamics of dangerous phenomena to possible measures:

Table 2: Synthesis of the possible measures according to the effects and dynamics of the dangerous phenomena

		Reorganization of indoor and outdoor workspaces	Warning + Sheltering people in a protection room	Warning + Sheltering people in a refuge area	Warning + Evacuation outside the exposed area	Protection barriers within the activity	Building reinforcement measures
Continuous thermal effects	Immediate	Yes (1)	No (2)	No (2)	No	Yes	Yes (4)
	Temporized		Yes	Yes	No (5)		
	Delayed		Yes	Yes	Yes		
Transient thermal effects	Immediate		No (2)	No (2)	No		
	Temporized		Yes	Yes	No (5)		
	Delayed		Yes	Yes	Yes		
Overpressure effects	Immediate		No	No	No		
	Temporized		Yes	Yes (3)	No		
	Delayed		Yes	Yes (3)	Yes		
Toxic effects	Immediate		No (2)	No	No (5)		
	Temporized		Yes	No	No (5)		
	Delayed		Yes	No	Yes		

(1) Potentially requires additional measures

(2) Unless the building (or personal protective equipment for people outside in case of a toxic cloud) provides a first protection allowing people time to reach the protection room or the refuge area, once the alert is given

(3) If the overpressure effects are less than 50 bar and the refuge area is not likely to receive glass breakage

(4) Potentially requires additional organizational measures

(5) Unless employees have personal protective equipment for toxic effects and / or distance to exit the exposed area is low

[Table is invalid in case of cumulative effects]

After this phase of individual diagnosis specific to each company, whether or not the activity can take care of the chosen measures alone, a more collective reflection could be conducted on the PPRT area involving stakeholders (local authorities, SEVESO establishments, enterprises association...).

This approach could allow:

- mutualisation of the individual measures identified by each activity;
- identification of shared organizational measures in the area;
- a finer approach for the implementation of relevant barriers

2.5 Step 5: Implementation of selected measures and monitoring

Whatever the chosen and implemented measures, it's necessary to ensure their effectiveness over time. Physical protections must be maintained. Organizational arrangements require testing. It is recommended to adopt a process of monitoring and continuous improvement.

3. Conclusions

The method now needs to be applied and to be improved taking into account the feedback of users. Today there are still few concrete applications.

The main difficulty lies in the fact that the activities must first be informed of the rules applicable to them in view of the PPRT, which may take time, and that they are willing to engage in the process of technological risks integration for their employees. Sen

Sensibilization actions are currently underway for the concerned PPRTs among the 392 PPRTs in France.

Acknowledgments

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