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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 clear) further away from the danger.
This article presents a methodology (5 main stages) to help the activities concerned by a PPRT (more particularly those located in the blue zoning) to implement and optimize their protection.
Since the publication of the document presenting the methodology (Résiguide) (Favre D. et al, 2017), first cases of application have been made. The article will be an opportunity to highlight the positive aspects of the proposed methodology and the difficulties encountered.

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, red and blue zones (see Figure 1):

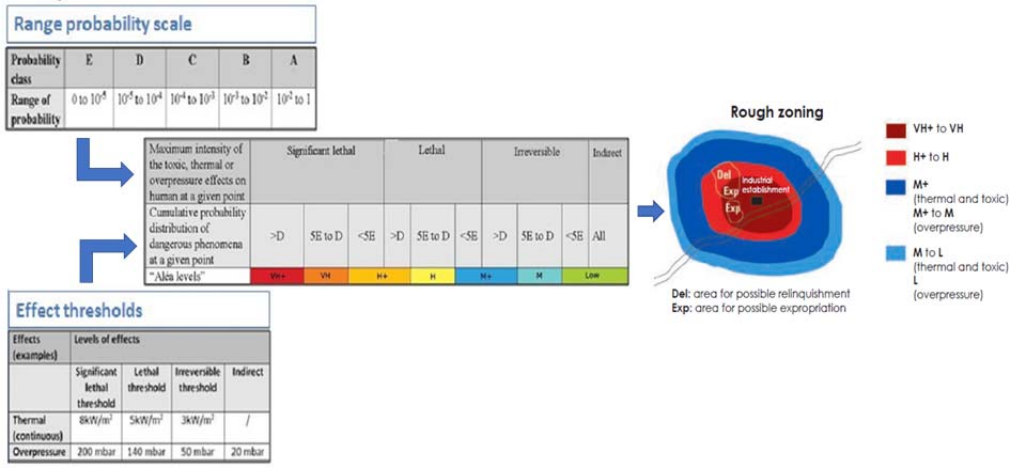

Figure 1: Rough zoning of the PPRT

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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 in 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 in the surroundings of SEVESO sites follows a sequence in 5 steps, as detailed below:

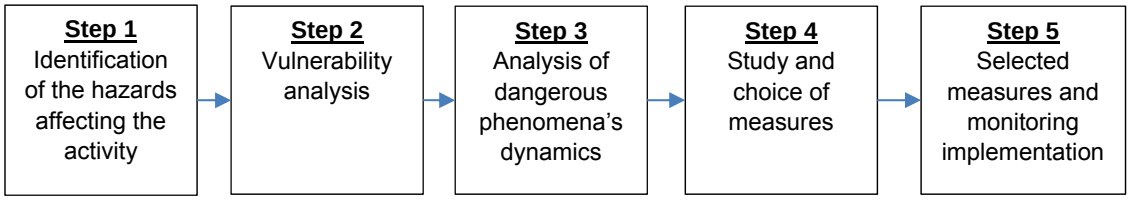

Figure 2: The 5 steps of the methodology for the integration of technological risks for activities located in the surroundings of SEVESO sites

2.1 Step 1: Identification of the hazards affecting the activity

This step's objective 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.

These data are available in the PPRTs documents, disseminated by internet and / or by the State services on specific request. It is also possible to contact the upper-tier SEVESO sites for additional information.

2.2 Step 2: Vulnerability analysis

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 dangerous phenomena's dynamics

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 BLEVE
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/m^2) 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.

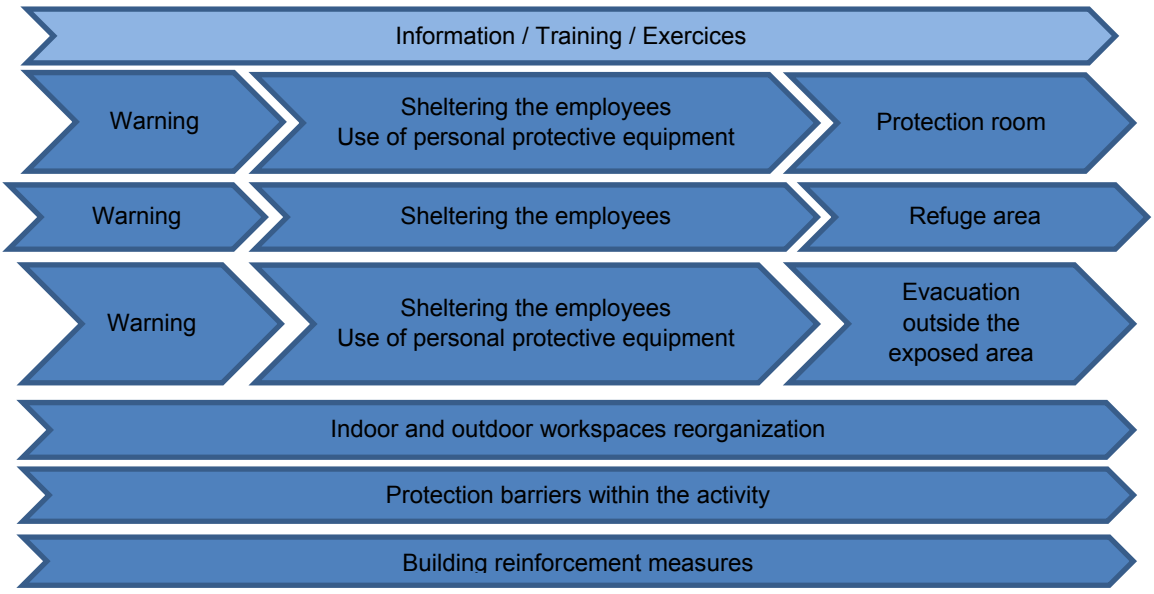

Figure 3: List of possible measures for the protection of people in activities near the SEVESO sites

Each measure is here 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 and 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.
- Indoor and outdoor workspaces reorganization
  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 neighbouring 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 (building reinforcement) 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 (5)		
	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: Selected measures and monitoring implementation

Whatever the chosen and implemented measures, it's necessary to ensure their effectiveness over time.
Physical protections must be maintained. For example, it is preferable to avoid making holes in the walls of a protection room to keep it tight against toxic effects, to store nothing in the room and to regularly replace the equipment useful during the crisis.
Organizational arrangements require testing. During regular exercises, people (employees and guests) learn to follow the instructions which then become reflexes and will be ready in case of technological accident. In addition to this educational dimension, the exercises reveal possible dysfunctions, and as a result, the procedure can be readjusted.
It is recommended to adopt a process of monitoring and continuous improvement.

3. Discussion

Since the publication of the document presenting the methodology (Résiguide) (Favre D. et al, 2017), first cases of application for this methodology have been made.
The users recognize that the methodology is useful for initiating an approach and gives practical tools for implementing it and for answering questions that may be asked.
However, users have identified subjects on which the Résiguide did not provide enough information. For example:

- How to take into account the notion of dynamics for dangerous phenomena when information or data are missing?

- How to define the common strategy of protection when there are several companies in the same building?
- How to manage possible confusion between an industrial risk alarm and a fire alarm, the instructions being different?
- How to manage the entry of people who would be outside at the time of the alert (parking, street...) and who would like to take refuge inside the buildings, while the activities either maintain the effectiveness of the protection room?
- What kind of individual protection equipment can be used in case of industrial accident, especially for toxic cloud? What are the conditions for using masks? How effective are they?
- How can shops set up a confinement room with no space?

The objective is now to try to improve the method taking into account the feedback of users.
Moreover, despite the existence of the Résiguide methodology, we observed that activities around upper-tier SEVESO sites have difficulties to integrate technological risks, since they ignore the risks, their obligations, the actors to whom to turn and also because of lack of human and financial resources…
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, sensibilization actions are currently underway for the concerned PPRTs among the 392 PPRTs in France.
Except for those who already have competent internal staff (Health, Safety and Environment department) or who already have a risk culture, most activities have difficulty getting involved on their own, without outside help. Assistance of experts is often required for technical studies of the vulnerability of buildings, for the search for suitable protection solutions…
Engagement in the integration process of technological risks is facilitated when there is local coordination for the implementation of measures, such as an association or local authorities. The required resources can be shared to build a collective response for several activities in the same area.
The technological risks integration should also concern public equipment (school, stadium, gymnasium, sewage treatment plant, prison...), placed under the responsibility of local authorities. For these facilities, the process is often even more difficult than for activities, due to the variety of concerned equipment, with varied and sometimes vulnerable people (children, old people…), users who are not aware of the risks or are not controlled. Furthermore, the absence of funding and the multiplicity of actors makes any initiative complex. Since the beginning of this year, a methodology with practical tools (Favre et al., 2020) is available for public facilities.

4. Conclusion

Even if it can be further improved to better take into account the diversity and specificities of the activities, the approach proposed in the Résiguide can nevertheless help companies located in PPRTs blue zones to prepare for an industrial accident.
The objective is to bring out a culture of risk around upper-tier SEVESO sites, to minimize the impacts on the potentially exposed population and more resilience in the territories that could be affected after such a disaster.

Acknowledgments

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