



Exploitation of the Results of Land Use Planning QRA Analysis to Focus the Inspection of Seveso Plants in Wallonia (Belgium) on External Safety Aspects

Damien Beaudoin^a, Christian Delvosalle^a, Nathael Cornil^b, Jérémie Delcourt^a, Joachim Nourry^a, Anaig Rosmorduc^a,

^aUniversity of Mons, Major Risk Research Centre (MRRC), 56 Rue de l'Epargne, 7000 Mons (Belgium)

^bPolyris SPRL, 2 rue René Descartes, 7000 Mons (Belgium)

damien.beaudoin@umons.ac.be

In the context of the transposition into Belgian law of the Directive 96/82/CE (Council of the European Union, 1996), also called Seveso II Directive, regional authorities are, in particular, responsible for the inspection of Seveso establishments with regards to external safety (Belgian Official Journal, 2001). Moreover, in Belgium, regional authorities have the responsibility to maintain appropriate distances between establishments covered by the Directive and various areas. To apply this Seveso Directive request (article 12), the Walloon Region developed a methodology to quantify individual risk generated by each Walloon Seveso sites.

The Walloon approach selected for the risk assessment and the determination of the "consultation zones" is a probabilistic one with particular assumptions (Delvosalle et al, 2006). This methodology which can be summarized in six steps is based on the use of the DNV software Safeti. Amongst the tools available in this software, the individual risk ranking report permits to determine the composition of risk at specific locations from the result of the modelling.

Due to a reorganization of the Walloon regional inspection department, a reflexion was begun to develop, for regional authorities, a more specific inspection method for external safety which must permit to identify the most critical installations for the safety beyond the fences of the plant. This method is similar to a classical risk based inspection (Vianello et al, 2013) method but adapted to Walloon land use planning methodology. In fact, it is based on the result of the modelling of the global risk generated by the plant and the analysis of the individual risk ranking report at specific locations wisely defined by the user. This result allows identifying the installations most contributing to the external risk.

However, this method must be used with caution (Bragatto et al, 2012). Indeed, this method permits to identify the most important contributors to the external residual risk by taking into account all safety barriers because it is based on land use planning modelling. However, this prioritisation is valid only whether that all safety barriers operate correctly, are properly maintained and are accurately modelled. So, this individual risk ranking report based on inspection method is an additional tool available for inspection teams but it does not totally replace a classical inspection method and reinforces the interest to inspect all safety barriers which are, of course, a major key for internal and external safety.

1. Introduction

In 1982 was published the Council Directive 82/501/EEC on the major-accident hazards of certain industrial activities (Council of the European Union, 1982). The aim of this first "Seveso" Directive was to prevent major accidents which might result from certain industrial activities and to limit their consequences for the man and the environment. Indeed, industrial establishments can store large quantities of dangerous substances and accidents, like the Seveso accident in 1976, stressed the need to regulate their using and to define a common policy in the field of prevention of industrial risk across the European Economic Community.

In 1996, this Directive was replaced by the Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances (Council of the European Union, 1996) also called "Seveso II" Directive. This Directive, as the Amending Directive published in December 2003 (European Parliament and Council of the European Union, 2003) widened the scope and amongst others, stressed the need to pay particular attention to the land use planning aspects after disasters of Enschelde (2000) and Toulouse (2001).

The last version, the Directive 2012/18/EU (European Parliament and Council of the European Union, 2012) was adopted the 4th July 2012 due to, in particular, the adaptation of the Directive to the CLP Regulation. This Seveso III Directive which must be transposed into the national legislation of each Member State reinforces the requirements for inspection and communication to the public.

Pending transposal of the Seveso III Directive in Belgium, Belgian authorities refer to article 12 and article 18 of the Seveso II Directive, transposed into Belgian law in a cooperation agreement between the Federal State and Flemish Region, Walloon Region and Brussels-Capital Region (Belgian Official Journal, 2010) for land use planning and inspection aspects.

The article 12 specifies that Member States shall ensure that their land-use policy takes account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest.

The article 18 specifies that Member States shall ensure that the competent authorities organize a system of inspections, or other measures of control appropriate to the type of establishment concerned. Those inspections or control measures shall not be dependent upon receipt of the safety report (for upper tier Seveso Plant) or any other report submitted. Such inspections or other control measures shall be sufficient for a planned and systematic examination of the systems being employed at the establishment, whether of a technical, organizational or managerial nature.

In Belgium, land use planning and inspection for external safety aspects are regional issues (Belgian Official Journal, 2010). So, at the time of a reorganization of the Walloon regional inspection department, a reflexion was begun to develop a more specific inspection method for external safety which must permit to identify most critical installations for safety beyond the fences of the plant. This method is similar to a classical risk based inspection (RBI) method but adapted to the Walloon land use planning methodology.

2. Walloon land use planning policy

The actual Walloon land use planning methodology was developed in 2003 through collaboration between regional authorities and the Major Risk Research Centre of the Faculty of engineering of the University of Mons (UMONS – MRRC). This method is similar to a classical probabilistic approach for risk assessment based on the concept of "consultation zones" (Delvosalle et al, 2006). These consultation zones are based on individual risk curves calculated for all Walloon Seveso Plant by the MRRC.

Compared to classical Quantitative Risk Assessment (QRA), the Walloon methodology only quantifies individual risk (not societal risk) and uses first irreversible effects rather than lethality effects as presented in Table 1. These threshold values concerning the three types of effects (overpressure, thermal and toxic effects) are fixed by the Walloon Government and specified in the Vade-Mecum of the Walloon Region (Ministry of Walloon Region, 2005).

Table 1: threshold values in the Walloon methodology (Ministry of Walloon Region, 2005)

Type of effect	Threshold value
Thermal effects	6,4 kW/m ² during 20 s or $2,376 \times 10^6 (\text{W/m}^2)^{4/3} \cdot \text{s}$
Overpressure effects	50 mbar
Toxic effects	LBW (Threshold life-threatening (Ministry of Housing, Spatial Planning and the Environment, 2007)) Similar to ERPG 3

The whole methodology for quantifying individual risk and permitting the definition of consultation zones for each Walloon Seveso plant can be summarized in six main steps as shown in Figure 1. Due to its use (land use planning policy), a critical step of this method is, of course, the selection of credible scenario leading to consequences outside of the plant (Tugnoli et al, 2012). In Wallonia, this step is entirely systematised and formalised (Ministry of Walloon Region, 2005). Moreover, the key step is the combination of deterministic approach and probabilistic approach with the QRA software Safeti (DNV Software) in order to obtain individual risk for the plant which is defined as "frequency to suffer some damage from an accident in a plant, for a person located at a given location during one year, permanently and with no protection" and is presented as iso-risk curves in overprinting geo-referenced.

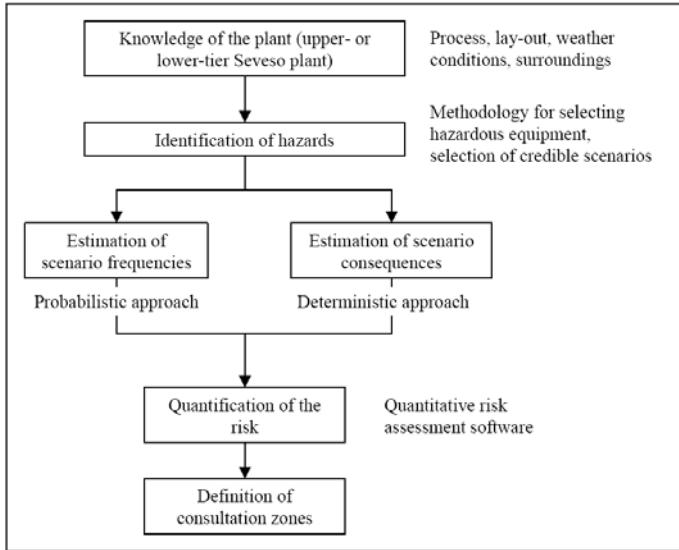


Figure 1: summary of the steps of the Walloon land use planning methodology (Delvosalle et al, 2006)

2.1 Risk ranking points and individual risk ranking report

Iso-risk curves are not the only interesting results available in Safeti software. Indeed, some interesting tools are included in the software like risk ranking points (RRP) which permit to know the exact composition of individual risk at a specific location. In fact, the individual risk ranking report shows the contribution of each scenario of accident to the individual risk at the locations specified by RRP. The report can rank the scenarios according to their contribution and so permits to identify the scenarios that cause the highest risk at a given risk ranking point. These risk ranking points are placed on a map like presented in Figure 2 graphically or by specifying geographical coordinates of the location.

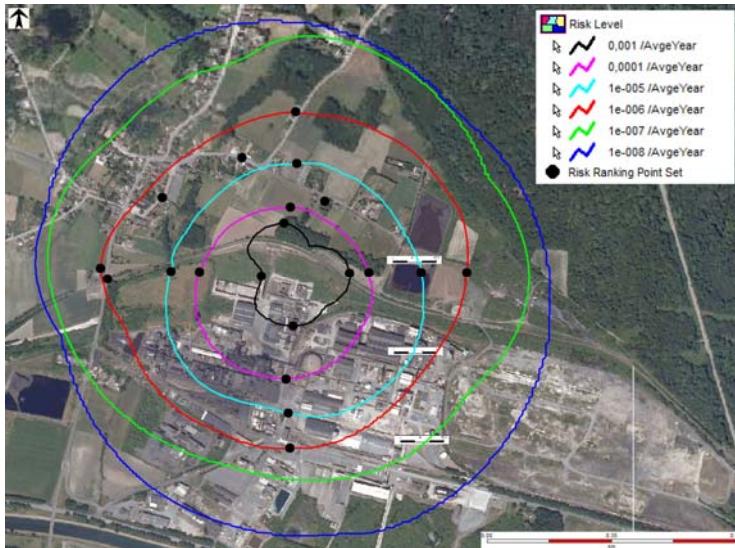


Figure 2: Example of placement of RRP (black spots) on risk map (result of LUP study)

In practical terms, these points of interest are placed by user at specific locations in function of risk levels or vulnerability levels. For example, it is interesting to know the risk composition for each iso-risk curve at the four cardinal points but it is also very interesting to know the exact composition of risk at high vulnerability locations like elementary schools, hospitals or railway stations.

After the risk calculation, the individual risk ranking report provides the risk composition for each RRP placed by the user as presented in Table 2.

Table 2: Example of data extracted from a RRP placed at 10⁴/year East

Equipment	Scenario	Risk	% risk
Transfer pipe propylene oxide	Line rupture – interruptible (300s)	5.02E-5	48.69
Transfer pipe propylene oxide	Leak 0,22D – interruptible (300s)	1.72E-5	16.68
Transfer pump propylene oxide	Leak 25mm – ininterruptible	1.56E-5	15.16
Unloading flexible pipe ethylene oxide	Line rupture – ininterruptible	4.53E-6	3.59
Acrylonitrile reactor	Leak 100mm	1,28E-6	1.25
Transfer pump propylene oxide	Rupture – ininterruptible	1,15E-6	1.12
Tank storage ethylene oxide	Leak 35mm	1,04E-6	1.10

Note that depending on the risk level considered, there are different major contributor to the risk. Near main dangerous installations, common scenarios are, obviously, major contributors. However, with increasing distance, scenarios with lower frequencies of occurrence but more serious consequences could be predominant. So, beyond the fences of the plant, information from RRPs is very interesting because it permits to identify installations which represents higher risk between high frequency events (usually with low consequences) and more catastrophic events (usually with lower frequencies). Obviously, the interest of this information is reinforced for plants including a high number of dangerous installations.

3. Risk ranking points to prioritize inspection

In the previous paragraph, it clearly appears that information from RRP could be very interesting for inspection for external safety aspects because it shows most contributors to the risk. However, this method must not replace a classical inspection method (based on permit conditions, safety report, etc.) but can care additional information specific to external safety. Moreover, we have to be sure that land use planning modelling is properly implemented.

The selection method proposed here is to select or not equipment based on two criteria.

3.1 Selection based on percentage of risk of equipment for each RRP placed

As it appears in Table 2, same equipment can be found several times among contributors to the risk at a specific location. A first criterion is so to select main equipment responsible of risk for each RRP placed. For this, we need to sum contributions of each scenario associated with a same device and we select equipment which represent more than a specific percentage of risk at the RRP studied (for example, 25%). Then, we perform this method for each RRP placed at the four cardinal points of each risk level but also for each vulnerable location beyond the fences of the plant. An example is presented in Table 3.

Table 3: Example of participation in risk of each device for each RRP

Equipment	10-3				(...)	10-6				House School		
	E	N	W	S		E	N	W	S	(North)	(East)	
Transfer pump propylene oxide	88.5	24.8	63.8	84.1	(...)	0.0	0.0	0.0	30.7	14.5	16.9	
Unloading flexible pipe ethylene oxide	0.4	35.7	21.8	0.2	(...)	32.2	59.7	38.8	5.1	30.5	25.5	
Transfer pipe propylene oxide	9.2	1.3	2.2	9.8	(...)	17.1	5.6	6.3	48.3	14.8	2.6	
Wagon propylene oxide	0.2	1.3	1.0	0.2	(...)	1.7	19.3	38.0	0.2	8.1	32.9	
Unloading flexible pipe propylene oxide	0.3	35.8	4.8	0.1	(...)	0.0	0.0	0.0	0.0	24.3	10.6	
Reactor R481	0.3	0.1	0.1	0.2	(...)	48.1	5.4	5.2	11.9	1.5	1.9	
Wagon ethylene oxide	0.0	0.1	0.1	0.0	(...)	0.9	10.0	10.9	0.1	1.3	4.7	
Tank storage ethylene oxide	0.3	0.1	0.5	0.2	(...)	0.0	0.0	0.8	2.5	3.4	3.8	
Tank storage propylene oxide	0.3	0.1	1.2	0.6	(...)	0.0	0.0	0.0	1.2	1.4	1.0	
Pipe natural gas	0.2	0.0	0.7	0.0	(...)	0.0	0.0	0.0	0.0	0.0	0.0	
Unloading pipe propylene oxide	0.0	0.6	3.3	0.1	(...)	0.0	0.0	0.0	0.0	0.1	0.1	
Transfer pipe ethylene oxide	0.0	0.0	0.1	2.4	(...)	0.0	0.0	0.0	0.0	0.0	0.0	
Unloading pipe ethylene oxide	0.0	0.1	0.4	0.0	(...)	0.0	0.1	0.0	0.0	0.1	0.1	
Reactor R401 acrylonitrile	0.0	0.0	0.0	0.4	(...)	0.0	0.0	0.0	0.0	0.0	0.0	
Reactor 412-01 acrylonitrile	0.0	0.0	0.0	0.5	(...)	0.0	0.0	0.0	0.0	0.0	0.0	
Reactor R301 acrylonitrile	0.0	0.0	0.0	0.6	(...)	0.0	0.0	0.0	0.0	0.0	0.0	

3.2 Selection based on percentage of overall risk equipment

As it appears in Table 3, some equipment can be found several times among main contributors to the risk for different RRP while others only appear at one or two specific locations. Therefore, the second criterion

is based on the percentage of overall risk equipment. This percentage is in fact the sum of participation in risk of all scenarios for a same device and for all RRP divided by the number of RRP.

Once again, equipment is held or not if the total percentage of its participation in the risk is greater or not than a threshold value (for example, 10 %).

To return at example described in Table 3, it is very simple to obtain the percentage of overall risk of equipment based on this table by summing percentage of risk for a same equipment for each RRP divided by eighteen in this case (the number of RRP). The overall percentage is so presented in Table 4.

Table 4: Example of overall percentage of the risk of each device

Equipment	Global Risk (%)
Transfer pump propylene oxide	30.1
Unloading flexible pipe ethylene oxide	22.2
Transfer pipe propylene oxide	17.8
Wagon propylene oxide	12.3
Unloading flexible pipe propylene oxide	5.6
Reactor R481	5.3
Wagon ethylene oxide	2.6
Tank storage ethylene oxide	2.1
Tank storage propylene oxide	0.9
Pipe natural gas	0.4
Unloading pipe propylene oxide	0.3
Transfer pipe ethylene oxide	0.1
Unloading pipe ethylene oxide	0.1
Reactor R401 acrylonitrile	0.1
Reactor 412-01 acrylonitrile	0.1
Reactor R301 acrylonitrile	0.1

3.3 Global selection

Based on an analysis of these two criteria, we can define a list of priority devices for external safety aspects as presented in Table 5.

Table 5: Example of equipment selected based on the two criteria proposed

Equipment	Global Risk >10 %	Risk participation at a cardinal RRP >25 %	Risk participation at a vulnerable location >25 %	Priority device?
Transfer pump propylene oxide	Yes	Yes	No	Yes
Unloading flexible pipe ethylene oxide	Yes	Yes	Yes	Yes
Transfer pipe propylene oxide	Yes	Yes	No	Yes
Wagon propylene oxide	Yes	Yes	Yes	Yes
Unloading flexible pipe propylene oxide	No	Yes	No	Yes

It is important to recall that the equipment selected must be studied in parallel with other priority devices based on study of conditions imposed in the permit or on study of the safety report. Indeed, a risk based inspection method has its limitations and to manage efficiently safety beyond the fences of a plant, this method needs to be apply in parallel of more conventional method (Bragatto et al, 2012). Moreover, the present selection is realised assuming that safety barriers, equipment and plant characteristics are properly taken into account in land use planning modelling and are properly maintained. In consequence, these aspects (maintenance, correct definition of hypotheses, etc.) must ideally be inspected too before the inspection of the equipment selected by the present method.

Finally, we must not forget that the goal here is not to dismiss equipment which would be less problematic but to focus the inspection on most hazardous equipment. So this method must permit to adapt the inspection to the criticality of the device, for example, by associating most problematic devices to higher frequencies of inspection.

4. Conclusions

Actually, before the total transposal of the Seveso III Directive, land use planning and inspection policies are regulated by the application of the Seveso II Directive transcribed into legislation of every Member States. In Belgium, this transcription made inspection for external safety aspects and land use planning

regional matters. Due to a reorganization of the Walloon inspection department, a reflexion was made to focus regional inspection method on external safety aspects linked to the land use planning policies.

Such a method was developed by using land use planning results. The Walloon land use planning methodology is a probabilistic one. The result, the global individual risk, is presented by iso-risk curves and is obtained by using the QRA software Safeti (DNV Software). Amongst the tools available in this software, risk ranking points (RRP) can provide the exact composition of calculated individual risk on specific locations. The approach proposed is so to export information about the most critical equipment by using this tool on interesting locations (cardinal points of each iso-risk curve and each particularly vulnerable location as schools, railway stations, etc.). This information is studied according to two criteria: The percentage of risk for a device at a specific location or the overall percentage of risk for a device for all vulnerable locations higher than a threshold value. This method permits to identify easily most hazardous equipment for the safety beyond the fences of the plant. Due to link with land use planning modelling, equipment selected must be inspected in parallel with the main hypothesis of the QRA (safety barriers operating, correct maintenance, etc.). Furthermore, this method must not be viewed as a new selection method for inspection but as an additional tool specific to external safety aspects and so must be applied in parallel with classical methods like study of the permit or the safety report for example.

Finally, this inspection selection method, to be effective, must be associated with an inspection management method for example by associating these devices to higher frequencies of inspection because not selected equipment, even if proportionally less hazardous, must not be dismissed from the global inspection program.

References

- Belgian Official Journal [M.B. 16/06/2001], 2001, Cooperation agreement between the Federal State and Flemish Region, Walloon Region and Brussels-Capital Region on the control of major-accidents hazards involving dangerous substances (21 June 1999) (In French).
- Bragatto, P., Delle Site, C., Faragnoli, A., 2012, Opportunities and Threats of Risk Based Inspections: the new Italian Legislation on Pressure Equipment Inspection, Chemical Engineering Transactions, 26, p. 177-182.
- Council of the European Union, 1982, Council Directive 82/501/EEC on the major-accident hazards of certain industrial activities, Official Journal L 230, 05/08/1982, Official Journal L 230, 05/08/1982 P. 01 - 18.
- Council of the European Union, 1996, Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances, Official Journal L 010, 14/01/1997 P. 13 – 33.
- Delvosalle C., Benjelloun F., Fiévez C., Niemirowski N., Tambour F., Brohez S., 2006, Land Use Planning around Seveso sites in Walloon Region (Belgium). Proceedings CHISA 2006. Praha, Czech Republic. 27-31 Aug. 2006. Lecture K4.1, p 01-09.
- European Parliament and Council of the European Union, 2003, Directive 2003/105/EC of the European Parliament and of the Council of 16 December 2003 amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances, Official Journal L 345, 31/12/2003, p. 01 – 37.
- European Parliament and Council of the European Union, 2012, Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC, Official Journal L 197/1, 24/07/2012, p. 97–105.
- Ministry of Walloon Region (Belgium), Directorate-General for natural resources and environment, Major accident hazards cell, 2005, Vade-Mecum, Technical specifications relating to all content and the presentation of safety surveys, hazard identification notification and safety report (Walloon part). p. 01– 62 (in French).
- Ministry of Housing, Spatial Planning and the Environment (Netherlands), 2007, Intervention threshold values for hazardous materials. p. 01–61 (In Dutch).
- Tugnoli, A., Gyenes, Z., Van Wijk, L., Christou, M., Spadoni, G., Cozzani, V, 2012, Scenario selection for land use planning purposes around "seveso" establishments, Chemical Engineering Transactions, 26, p. 417-422.
- Vianello, C., Maschio, G., Mura, A., Babolin, D., Gambato, F., Attori, C, 2013, Development of a RBI Tool for Inspection Management in Chemical Plants, Chemical Engineering Transactions, 31, p. 235-240.