Improvement of the hazard identification and assessment in application of the Seveso II directive (part II)

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IMPROVEMENT OF THE HAZARD IDENTIFICATION AND ASSESSMENT IN APPLICATION OF THE SEVESO II DIRECTIVE (PART II)

AMELIORATION DE L'IDENTIFICATION ET DE L'EVALUATION DES DANGERS DANS LE CADRE DE LA DIRECTIVE SEVESO II (DEUXIEME PARTIE)

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Summary

The Council Directive **96/82/EC** of 9 December 1996 on the control of major-accident hazards involving dangerous substances, known as Seveso II Directive, aims at the prevention of major accidents in high risk industries, and the limitation of their consequences for human beings and environment. Although rules are well established to identify maximal hazard potential, there is no recognised method for taking into account, in the assessment of risk level, safety devices and safety management systems implemented by operators.
This paper deals with the second stage of a global methodology aiming at better assessing benefits gained from safety devices and safety management systems, through accident scenarios selection.
The methodology presented in this paper enables risk **assessorsand** competent authorities to identify Reference Accidents Scenarios (RAS), by taking into account the influence of some safety barriers, in accordance with the Seveso II Directive requirements.
This method could help stakeholders involved in the public risk-based decision-making process to evaluate the safety level of high-risk establishments.
Since the risk management decisions are based on the risk assessment [12], and since the choices and hypothesis to define the RAS are arbitrary, there is a need to reach a consensus among all the stakeholders to limit the discrepancy in the decision and improve the transparency.

Résumé

La Directive européenne **96/82/EC** du 9 Décembre 1982 sur le contrôle des accidents majeurs impliquant des substances dangereuses, connue également sous le nom de Directive Seveso II, a pour objectif la prévention des accidents majeurs dans les sites industriels à hauts risques, et la limitation de leurs conséquences pour les populations et l'environnement. Bien que les règles soient bien établies pour l'identification du risque potentiel, il n'y a pas de méthode reconnue pour la prise en compte, dans l'évaluation du potentiel maximal de danger, des dispositifs de sécurité et des systèmes de gestion de la sécurité mis en œuvre par les exploitants.
Cet article traite de la seconde étape d'une méthodologie générale, qui vise à mieux évaluer les améliorations apportées par les dispositifs de sécurité et des systèmes de gestion de la sécurité, à travers la sélection des scénarios d'accidents.
La méthode présentée dans cet article permet aux évaluateurs du risque ainsi qu'aux autorités compétentes d'identifier les Scénarios Accidentels de Référence, qui prennent en compte l'influence de certaines barrières de sécurité, en accord avec les exigences de la Directive Seveso II.
Cette méthode pourrait aider les parties prenantes impliquées dans le processus décisionnel de gestion publique basé sur les risques, **afin** d'évaluer le niveau de sécurité des établissements à hauts risques.
Comme les décisions de gestion des risques sont basées sur l'évaluation des risques, et comme les choix et les hypothèses pour définir les Scénarios Accidentels de Référence sont arbitraires, il est nécessaire d'obtenir un consensus parmi les parties prenantes, afin de limiter les divergences dans les décisions et améliorer la transparence.

1. INTRODUCTION

1.1 Context

In several European countries, hazard potential around high-risk industries is often deducted from effect distances, as results of the evaluation of gravity and likelihood of major accident scenarios. Therefore, the identification of accident scenarios appears as a critical point in the risk analysis process, that should take into account measures related to "state of art" and philosophy of the SEVESO II Directive.

The Directive gives the rules to identify high-risk potential establishments with a precise criterion, which is the amount of hazardous substances handled.

The lessons leamt from the control of hazardous installations and improvement of the state of the art lead more and more to integrate the hazard reduction directly at the conception level, with the concepts of inherent safety.

Therefore, often the choices of some altematives in the control of the installation reduce significantly the hazard (size of the vessels, distance between two units or storage). It appears then clearly that the only consideration of the amount of hazardous substances handled on the site is too rough.

There is a need to take into account some more representative criteria in complement with the amount of substances.

Because of a lack of methodology, it is now particularly difficult to point out the influence of risk reducing measures, especially when determining accident scenarios. This difficulty is particularly relevant in France, where a deterministic approach is adopted **[1].**

The underlying philosophy of this approach is based on the idea that measures implemented to protect people from worst cases accidents will also protect them in case of an accident of less gravity, regardless of any probabilistic matters.

1.2 Proposition of an overall **methodology**

Regarding the considerations developed in the previous paragraph, an overall approach has been developed in order to valorise the positive results of safety devices and safety management **systems,** in an industrial group or in an industrial activity. The method, in a deterministic context, emphasises:

- The hazard potential inherent to an industrial plant, by the definition of **Maximum Physically Possible Scenarios** (MPPS) ;
- The influence of risk reducing measures described for example in standards, regulations, by the definition of the **Reference Accident Scenarios** (RAS) ;
- The benefits brought by safety devices and safety management systems, by the definition of **Residual Risk Assessment Scenarios** (RRAS).

These three stages of the general method are illustrated by **(Fig 1).**

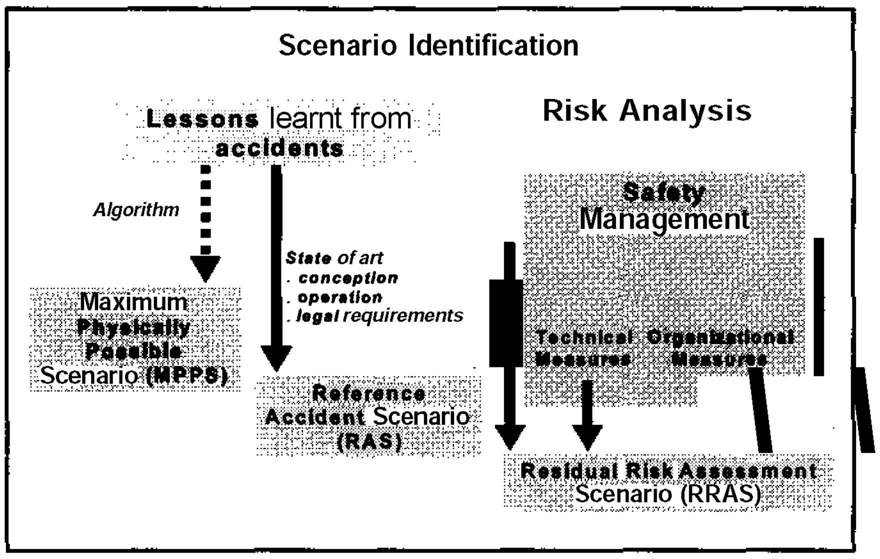

Figure 1 : Scenario Identification

This method is being developed with the French Competent Authorities in charge of the application of the Seveso II Directive **[7, 9].**

The following paragraphs deal with:

- a brief recall about the identification method of Maximum Physically Possible Scenarios, which is the topic of a paper presented at the 2001 ESREL Conference [6] ;
- safety barriers and their influence, through the identification of Reference Accident Scenarios (RAS) and Residual Risk Assessment Scenarios (RRAS).

Throughout the description of the methodology, some illustrations by a practical example will be given, based in particular on the study of a pressurised vessel of liquid chlorine at ambient temperature. These elements of illustration are referred to in the text by the symbol **"✂"**.

2. FIRST STEP: DETERMINATION OF MAXIMUM PHYSICALLY POSSIBLE SCENARIOS (MPPS)

The method to identify Maximum Physically Possible Scenarios (MPPS) is described in the paper presented at the 2001 ESREL Conference **[6].** The following paragraphs summarise the method.

2.1 Definitions and Hypothesis

MPPS identification is regarded as an attempt to quantity maximum hazard potential in industrial establishments, following an specific algorithm.

This algorithm is based on the labelling of the substances (Directive 67/548/EEC and Seveso II Directive), the conditions of their use (pressure, temperature, **solutions...**) and the type of containment.

As stated in the introduction, Maximum Physically Possible Scenarios characterise the hazard potential inherent to high-risk establishments. In a simpler way, it can be noticed that these scenarios determine the worst situations that could physically occur.

Generally, a scenario is assimilated as a succession of events presented in (Fig 2), which is inspired from the bow-tie approach presented in [3].

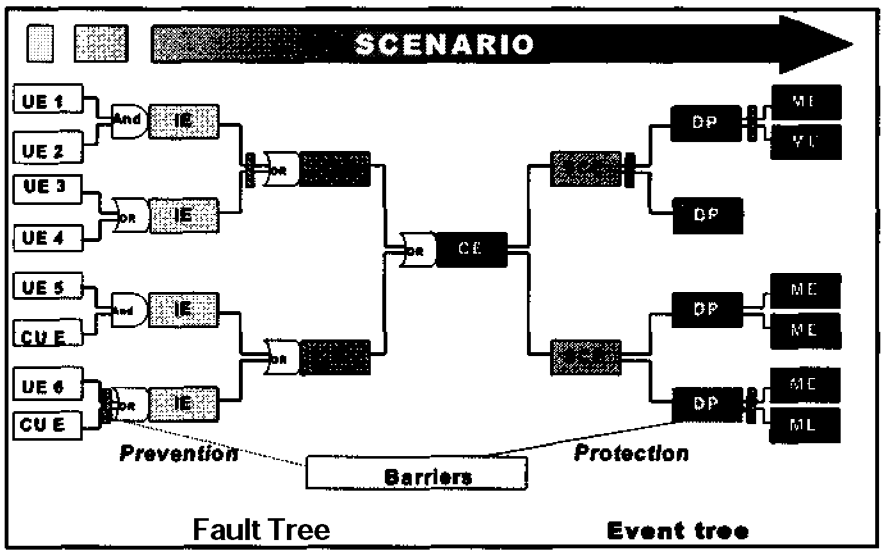

Figure 2: Accident Scenario Identification

At this stage, the methodology will enable to quantify the hazard potential of a unit by the definition of Maximum Physically Possible Scenarios (MPPS). For this **purpose,** it is important to identify the worst cases that could possibly occur, regardless of any probabilistic matters.

In consequence, the following hypothesis can be reasonably made to determine MPPS:

- the eventual prevention and protection barriers are supposed to be **inoperative,**
- there is no need to determine the possible causes of the accident. The MPPS must be representative of the worst cases. As a matter of fact, such scenarios are most of the time justified by external aggressions such as natural catastrophes **(earthquakes, ...)** or domino effects.

Thus, in a deterministic approach, a MPPS depends only on the nature and the properties of the dangerous substance, and the characteristics of the equipment involved. Therefore, MPPS is **fully determined by the following triplet:**

- the Critical Event (CE), which is determined by the physical state of the substance handled,
- the Secondary Critical Events **(SCE),** that can be completely defined by the type of equipment and the conditions of use of the substance,
- the Dangerous Phenomena (DP), that are linked to the physical state and the hazards of the **substance,** regardless of the type of equipment involved.

2.2 Methodology for MPPS identification

2.2.1 First step: definition of Critical Events and Secondary Critical Events

The first step of the methodology consists in determining the Critical Event. Clearly, this Critical Event is closely linked to the physical state of the substance involved.

X *For a pressurised vessel of chlorine, the Critical Event is a loss of containment.*

Once the critical event is characterised, it is possible to deduce the possible Secondary Critical Events (SCE) from the type of equipment, by using a classification of industrial equipment, based upon the work performed by the Major Risk Research Centre (Faculté Polytechnique de Mons, Belgium) on domino effects [4, 5].

Practically, a matrix, called SCE matrix, is available for each equipment category and defines the Secondary Critical Events, according to the operating conditions of use of the hazardous substance [6].

X *For a pressurised vessel, the SCE matrix is described as follows* **[6]**:

1. In case of a substance handled under pressure above boiling point (two-phase equilibrium), the SCE are:
- *For a catastrophic rupture: puff (including aerosols), missiles and overpressure;*
- *For a breach or pipe rupture: gas release, two-phase release (jet) and pool formation.*

2. In case of a substance handled below boiling point with inert gas (liquid state), the SCE are:
- *For a catastrophic rupture: missiles and overpressure;*
- *For a breach or pipe rupture: pool formation.*

3. In case of a substance handled in a purely gaseous state, the SCE are:
- *For a catastrophic rupture: gas puff, missiles and overpressure;*
- *For a breach or pipe rupture: gas release.*

2.2.2 Second step: definition of Dangerous Phenomena (DP)

In order to complete the definition of Maximum Physically Possible Scenarios, the Dangerous Phenomena (DP) must be identified.
In a similar way as in step **1**, the definition of the Dangerous Phenomena is realised, regardless of the type of equipment, considering only the properties of the substances (hazards and physical state).

To classify the hazardous substances, the methodology relies on the Council Directive 67/548/EC on the classification, labelling and packaging of dangerous substances, and more precisely, on the definition of the risk phrases.

X *Chlorine is classified as a toxic substance (risk phrase: R23). The only Dangerous Phenomenon to consider is then toxic gas dispersion.*

2.2.3 Third step: checking the consistence between DP and SCE

Finally, it is necessary to ensure that SCE identified may actually lead to the DP regarded. For this purpose, the methodology suggests the use of a matrix, called the SCE/DP matrix.
In most cases, the consistence between SCE and DP is immediate.

X *In the practical case of a pressurised chlorine vessel, the consistence of SCE and DP is immediate.*

It is now possible to completely define the ***MPPS*** *in order to build the following tree (fig 3).*

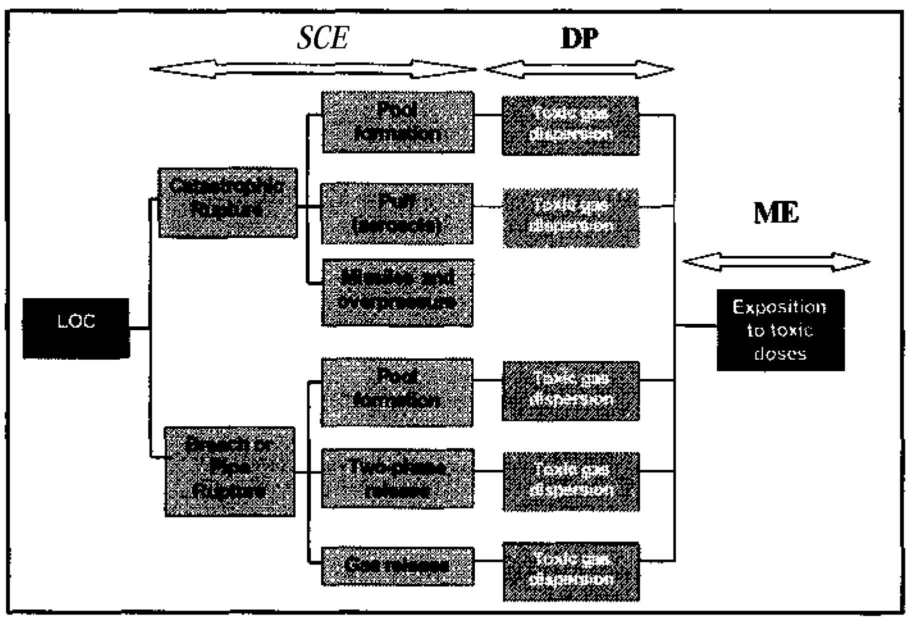

Figure 3: MPPS for a pressurised vessel of chlorine

2.3 Improvement of the approach

The identification of the possible scenarios according to the combination of the equipment and hazardous substance results of a systematic algorithmic approach.

This method applies to most frequently met cases in high-risk industries and follows a deterministic approach.

MPPS identification should not be regarded as a final goal, but as an attempt to quantify maximum hazard potential in industrial establishments.

It is of interest to carry on the hazard assessment that has to be implemented in accordance with the requirements of the Seveso II Directive.

3. FURTHER DEVELOPMENTS: SAFETY BARRIERS, IDENTIFICATION OF REFERENCE ACCIDENT SCENARIOS (RAS) AND RESIDUAL RISK ASSESSMENT SCENARIOS (RRAS)

The present chapter aims at presenting the method for identification of Reference Accident Scenarios (RAS), and Residual Risk Assessment Scenarios (RRAS). The method had been developed in a project supported by the French Ministry of Environment. The approach is described in a draft document [7] and was applied in five "Seveso II" establishments in France [8].

RAS and RRAS are based on MPPS, completed with the influence of safety barriers.

In this chapter, the first paragraph presents some preliminary considerations about safety barriers.
The second paragraph deals with the identification method of RAS, from theory to practical examples.
In the third paragraph, some preliminary considerations are given about identification method of RRAS, which is currently in progress.

3.1 **Safety** barriers

A safety barrier can be defined as a specific safety element, which aims at achieving a safety function. This paragraph presents:

- A definition of safety functions,
- A method for identification and classification of the safety barriers,
- An illustration of the method by some case studies.

3.1.1 *Definition of safety functions*

The bow-tie approach adapted from [3] and presented in Fig. 2 describes accident scenarios as succession and / or a combination of events. The transition from one event to another more catastrophic can be controlled by safety functions. A safety function can be achieved either by intrinsic or inherent safety, included in the design of equipment, or by additional safety barriers.

The safety level of an installation depends on the reliability of the safety functions, achieved by the quality of safety barriers [9].

X *For a pressurised vessel of chlorine, some relevant safety functions are:*
- *prevent an overpressure,*
- *prevent an overflow,*
- *prevent from corrosion,*
- *protect from mechanical shocks,*
- *protect from thermal effects,*
- ...

3.1.2 Method for identification and classification of the safety barriers

When studying an industrial case, a step of the risk management consists in identifying the safety barriers that achieve the safety functions identified in the risk analysis. One or several safety barriers can achieve a safety function.

In order to identify the safety barriers, information can be found in national and international standards and regulations, which present safety requirements for design and operation of industrial unit. The current practices or "state of the art" for a given unit may also provide a range of safety elements, which are often implemented in high-risk industries.

Legal and normative requirements, as current practices, are generally resulting of lessons learnt from passed major accidents.

The identified safety barriers can be classified, according to several criteria.

A first obvious classification consists in distinguishing prevention, and mitigation / protection barriers. Several detailed classification methods have been analysed in the reference **[10].** From this analysis, it is proposed to classify the safety barriers as follows:

- **inherent safety barriers:** barriers related to the design of the equipment,
- **additional passive barriers:** barriers that don't require an external power source for its successful operation,
- **additional automatic barriers:** safety system with full automatic actions from detection to the return to a safe state,
- **additional manual barriers:** safety system that requires manual actions by an operator to the return to a safe state.

X *For a pressurised vessel of chlorine, one of the relevant safety functions is the prevention of an internal overpressure. It can be achieved:*
- *by designing the vessel for the maximum possible pressure (inherent safety barrier),*
- *by pressure relief valve (additional passive barrier),*
- *by detection and automatic subsequent actions (automatic safety system),*
- *by detection and manual actions (manual safety system).*

The implementation of this classification is quite simple and is of relevance to highlight the inherent and passive safety barriers that contribute to the risk control with often a high availability. When identified, they can be mentioned in the safety report required by the Seveso II Directive.

This approach can be completed with an assessment of the quality of the barriers according to the following criteria [10]:
- efficiency,
- availability (reliability and maintainability),
- other criteria related to the practical use of the barriers (response time, operational in given range of ambient conditions like temperature, pressure, relative humidity, frost, corrosive **atmosphere...).**

The inherent and passive safety barriers are obviously characterised by a high level of performance regarding these criteria.

3.1.3 Case studies

Some current Initiating Events, Critical Events and Dangerous Phenomena are listed here below, and for each event, several safety barriers are proposed (non-exhaustive). The category of the safety barrier is specified as follows:

1. **inherent** safety barriers,
2. **additional** passive barriers,
3. **additional** automatic barriers,
4. **additional** manual barriers.

a) Safety barriers on Initiating Events

- Overpressure, overflow, under-pressure: quality of materials (1), steel thickness **(1),** rupture disk, vent (2);

- External or internal corrosion: quality of materials **(1),** steel thickness (1), cladding (2), painting (2), coating (2), cathodic protection (2), inspection (4), tests (4);

- Human error: operation(s) requiring specific qualification and training (4);

- Mechanical shock: quality of materials (1), steel thickness (1), double containment (2), wire netting (2), pipe-in-pipe configuration (2);

- Thermal effects: fire wall (2), foam systems (3), water curtains (3).

b) Safety barriers on Critical Events

- Ignition: requirements of hazardous classification areas (3);

- Pool: bound (2);

- Puff: containment room (2);

- Gas, liquid or two-phase release: reduced pipe diameter (1), non-return valve (2).

c) Safety barriers on Dangerous Phenomena

- Toxic gas dispersion: ventilation and treatment system (2);

- BLEVE (Boiling Liquid Expanding Vapour Explosion) and Boil Over: deluge systems (3).

3.2 Identification of Reference Accident Scenarios (RAS)

3.2.1 Theoretical method development

In the framework of the Seveso II Directive, there is a need to assess the hazard potential and demonstrate its control. The ASSURANCE project **[11]** shows the discrepancies between the assessment of the risk experts, particularly for the definition of accidents scenarios.

This result is due to the numerous parameters involved in the definition of a scenario, and the arbitrary choices made by the experts for these parameters.

In the approach, it is proposed to define more precisely Reference Accident Scenarios that can be compared to the current concept of "credible scenarios" or "realistic scenarios".

These RAS are deterministic scenarios, but they are not representative of the "worst case scenarios".

RAS are based on MPPS, completed with the influence of some supplementary risk reducing measures selected among all existing barriers. One of the main difficulties is the choice of the relevant barriers for the definition of the RAS.

It is proposed to select them according to the criteria mentioned in paragraph 3.1.2 (efficiency, availability and specific quality criteria): first, the inherent and passive safety barriers and second, some additional active and manual safety barriers that fit the criteria.

This selection reflects the current practice in risk assessment and are consistent with the lessons **learnt** from past accidents or emergency exercises.

In this paper, only the general approach is described as a framework to lead the risk assessment, which has to be completed by a more detailed risk analysis.

3.2.2 Case *studies*

In this paragraph, some case studies are proposed. They are related to a pressun'sed vessel of chlorine and linked pipelines.

X *For a pressurised vessel of chlorine and linked pipelines, MPPS are defined in the first chapter:*

- *the Critical Event is a loss of containment ;*
- *the MPPS are catastrophic rupture of the vessel, and breach* **or** *pipe rupture.*

French national regulation requires several safety elements for a pressurised vessel of chlorine and linked pipelines. Among them:

- *The vessel has to be located in a containment room,*
- *The containment room has to be equipped with ventilation and treatment systems,*
- *External pipelines have to be in pipe-in-pipe configuration.*

a) Definition of RAS for the catastrophic rupture of a pressurised vessel of toxic (liquefied) gas

Consequences of a catastrophic rupture depends mainly on:
- Stored mass,
- Internal pressure when accident occurs.

The stored mass is assumed to be the maximal capacity of tank, in accordance with operating conditions.

Storage pressure may be assumed to be:
1. normal operation conditions,
2. saturation pressure at ambient temperature (due to a failure of heating or cooling system if different of 1),
3. maximum pressure (not precisely defined: in a range of 1 to 3 times the proof test pressure).

In a conservative approach, for toxic (liquefied) gas such as chlorine, the most stringent case will be defined, according to pressure, meteorological conditions and toxicity thresholds, and in accordance with risk analysis.

X *First assumption:*
The vessel is located outside, without any containment room. So, catastrophic rupture of the vessel can be regarded as a Reference Accident Scenario.

X *Second assumption:*
The vessel is located in a containment room, protected from thermal effects and mechanical shocks. It is in conformity with pressure design codes and it is equipped of automatic safety system for overpressure and overflow. So, the catastrophic rupture of the vessel will not be regarded as a Reference Accident Scenario.

b) Definition of RAS from breach or pipe rupture of toxic (liquefied) gas

Even protected by containment room or pipe-in-pipe configuration, pipe rupture can be regarded as a Reference Accident Scenario.

Consequences of a breach or a pipe rupture depends mainly on:
- Leakage location,
- Release flow rate,
- Release duration.

The leak location is assumed to be on the highest diameter pipe (maximum flow rate). The direction and the height of jet depend on leakage location, as well as the release flow rate. The flow rate assessment takes into account upstream capacities, pipe and downstream capacities volumes, and also non-return valves.

For a rupture located downstream of pumps, compressors, or boiling vessels, the nominal flow rate of these equipment can be used.

The release duration is linked to safety barriers and their response time.

X *First assumption:*
The pipe is located outside, downstream of pumps, without any particular safety element. So, the duration of the leakage following the pipe rupture will be high for the Reference Accident Scenario (almost 30 minutes), because of a quite long time for detection by operator and manual shutdown action.

X *Second assumption:*
The pipe is located in a containment room, equipped with permanent ventilation and treatment systems. So, the duration of the leakage following the pipe rupture will be smaller for the Reference Accident Scenario (almost 10 minutes), because of an immediate detection and a quite short manual shutdown action. The ventilation and treatment systems will be taken into account in consequence assessment.

X *Third assumption:*
The pipe is used for loading or unloading operations, under surveillance, with emergency stops. So, the duration of the leakage following the pipe rupture will be low for the Reference Accident Scenario (almost 2 minutes), because of an immediate manual shutdown action.

3.2.3 Next steps

The work on the RAS is still going on with a working group involving risk assessors and Competent Authorities. It is intended to generalise the **above-described** examples to define a general and systematic approach based on clear principles.

When achieved, this approach will be shared with the other stakeholders involved in the risk decision-making process (industrialists, the public, public authorities, elected **representatives…).**

Since the risk management decisions are based on the risk assessment **[12],** and since the choices and hypothesis to **define** the RAS are arbitrary, there is a need to reach a consensus among all the stakeholders to limit the discrepancy in the decision and improve the transparency.

3.3 Identification of Residual Risk Assessment Scenarios (RRAS): **preliminary** considerations

In this paragraph, some preliminary considerations are given about the definition of RRAS, which is currently in progress.

RRAS is based on RAS, completed by the influence of specific technical and organisational risk-reducing measures.

The specific technical measures are generally similar to additional automatic barriers (for example emergency shutdown valves activated by gas detection).

The specific organisational measures, included in the safety management systems, are generally similar to additional manual barriers (for example emergency intervention procedures).

Thus, additional automatic and manual safety barriers are regarded for the definition of Residual Risk Assessment Scenarios.

However, they have to fit some safety requirements, related to their availability and reliability. These requirements and criteria will be defined in the next step of our works.

4. CONCLUSION

The methodology presented in this paper enables risk assessors and competent authorities to identify Reference Accidents Scenarios (RAS), by taking into account the influence of some safety barriers, in accordance with the Seveso II Directive requirements.

This method applies to most frequently met cases in high-risk industries and pursues a deterministic approach.

It is the second stage of an overall approach in order to better assess benefits and reliability of preventing and protecting measures, either technical or organisational, thanks to more detailed analysis, but without using any probabilistic method.

The first step of the methodology aims to highlight maximum hazard potential in industrial establishments, by the definition of Maximum Physically Possible Scenarios (MPPS).

The third and final stage of the methodology will enable to take into account specific technical and organisational measures, in the definition of Residual Risk Assessment Scenarios (RRAS).

The overall approach described in this paper represents an effort of rationalisation and harmonisation of the current practices to identify major industrial accidents. So as to achieve a level of full harmonisation, this method should be completed by the development of guidelines for the consequences modelling.

This method could help stakeholders in the public risk based decision-making process to evaluate the safety level of high-risk establishments:
- MPPS could be selected for emergency and intervention planning with emergency services,
- RAS could be selected for land use planning around hazardous installations,
- RRAS could be selected by an industrial operator for the demonstration of his efficient management of major-accidents hazards.

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REFERENCES

[1] Christou M.D. & Porter S., *Guidance on land-use planning as required by the council directive* ***96/82/EC,*** EUR 18695 EN, 1999

[2] Salvi O. and Gaston D, *Why changing the way to measure the risk ? Proceedings 9th Annual Conference Risk Analysis: Facing the New Millennium,* Rotterdam, The Netherlands. Edited by L.H.J. Goossens. Delft University Press, 1999

[3] Bellamy L., Van der Schaff *J Major Hazard Management: Technical-Management Links and the AVRIM2 Method,* in Seveso 2000 - Risk Management in the European Union of 2000: The Challenge of Implementing Council Directive Seveso II. November 10-12, 1999. Athens. Edited by the European Commission, Joint Research Centre, Major Accident Hazard Bureau.

[4] Delvosalle C., Fievez C. and Benjelloun F. *Development of a methodology for the identification of potential domino effects in "SEVESO" industries,* Proceedings 9th International Symposium on Loss Prevention and Safety Promotion in the Process Industries, volume 3, pp. 1252-1261, Barcelona, Spain, 4-7 may 1998.

[5] Delvosalle C., Benjelloun F., Niemirowsky N. and Bach V.T. *A Methodology for the Identification of Potential Domino Effects in "SEVESO" Industries and an Application Tool:* ***"DominoXL",*** Seminar on "Software Tools Relevant to the Seveso II Directive", Second Meeting of the Committee of Competent Authorities Responsible for the Implementation of Directive 96/82/EC, 43 pages, 13th October 1999, Turku, Finland

[6] Bemuchon E., Delvosalle C., Descourrière S., Salvi O. *Improvement of the hazard identification and assessment in application of the* ***Seveso*** *II Directive,* Proceedings of the European Conference on Safety and Reliability - ESREL 2001 - Torino / Italy / 16-20 Septembre 2001 - Edited by Politecnico di Torino

[7] Descourrière S., Salvi O. *Propositions* ***pour*** *la révision du Guide de Maîtrise de l'urbanisation.* INERIS DRA-07, December 2001. Draft document.

[8] Descourrière S., Salvi O. *Avis d'expert sur la détermination des zones de sécurité pour la maîtrise de l'urbanisation autour de 5 établissements à risques dans la région Midi-Pyrénées - Volet I* - INERIS, December 2001

[9] Gaston D., Salvi O. *Criteria for risk decision-making process related to hazardous installation: a French experience,* Proceedings of the 5th International Conference on Technology, Policy and Innovation - Delft / The Netherlands / 26-29 June 2001 - Edited by TU Delft

[10] Bouchet S., *Analyse des Risques et prévention des accidents majeurs (DRA-07) - Rapport intermédiaire d'opérations - Prise en compte de l'influence des barrières de sécurité dans l'évaluation des risques - Présentation des méthodes d'inspection TRAM, NIVRIM et AVRIM2.* June 2001, INERIS

[11] Lauridsen K., *Uncertainties in risk analysis of chemical establishments - the ASSURANCE project* - Proceedings of the Seminar « Progress on Research on Major Accident Hazards » - Anvers / Belgium / 10 October 1999

[12] *Land use planning around high-risk industries* - Guideline - Octobre 1990 - Edited by the "Secrétariat d'Etat auprès du Premier Ministre chargé de l'Environnement et de la Prévention des Risques Technologiques et Naturels Majeurs"