MONITORING AND INTERVENTION
FOR THE TRANSPORTATION OF DANGEROUS GOODS

D2.2: Methodology for Consequences Assessment

MITRA – FP6 – STREP (511361)

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Glossary

AEGL Acronym for Acute Exposure Guideline Levels. AEGLs represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 min to 8 h. AEGL-2 and AEGL-3, and AEGL-1 values as appropriate, will be developed for each of five exposure periods (10 and 30 min, 1 h, 4 h, and 8 h) and will be distinguished by varying degrees of severity of toxic effects. It is believed that the recommended exposure levels are applicable to the general population including infants and children, and other individuals who may be susceptible. The three AEGLs have been defined as follows:

AEGL-1 is the airborne concentration (expressed as parts per million or milligrams per cubic meter (ppm or mg/m3)) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Airborne concentrations below the AEGL-1 represent exposure levels that can produce mild and progressively increasing but transient and nondisabling odor, taste, and sensory irritation or certain asymptomatic, nonsensory effects. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL.

Alert code Internal system code transmitted in case an alert is generated by the system. It will be generated in two situations:

- when detecting a cargo parameter is out-of-limits
- when the vehicle driver presses the panic button

CAS number Chemical Abstracts Service registry number is a numeric designation assigned by the American Chemical Abstracts Service and uniquely identifying a specific chemical compound. This entry allows us one to conclusively identify a material regardless the name or naming system used.

Container Receptacle prepared for keeping each individual cargo. It is designed for the specific cargo carriage.

ERPG Acronym for Emergency Response Planning Guideline. ERPG numbers are developed by the Emergency Response Planning Committee of the American Industrial Hygiene Association (AIHA). They are defined as follows:

ERPG-1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.

ERPG-2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

ERPG-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

The term "one hour exposure" appears in the ERPG definition.
As of July 2002, the AIHA has published ERPG concentrations for 102 different chemicals. Typically the AIHA adds about seven chemicals per year to their list, and sometimes that organisation will change a value that it has established previously.

Hazard identification number

Indicates the potential risk represented by the cargo. It consists in two or three figures indicating the following hazards:

2. Emission of gas due to pressure or chemical reaction

3. Liquids (vapours) and gases flammability or self-heating liquid

4. Solids flammability or self-heating solid

5. Oxidizing (fire-intensifying) effect

6. Toxicity

7. Radioactivity

8. Corrosivity

9. Risk of spontaneous violent reaction

Doubling of a figure indicates an intensification of that particular hazard. Where the hazard associated with a substance can be adequately indicated by a single figure, this is followed by a zero.

If a hazard identification number is prefixed by letter 'X', this indicates that the substance will dangerously react with water.

International Chemical Safety Cards (ICSCs)

The international programme on Chemical Safety Project. ICSCs project is an undertaking of the International Programme on Chemical Safety (IPCS). An ICSC summaries essential health and safety information on chemicals. ICSCs are not legally binding documents, but consist in series of standard phrases, mainly summarising collected health and safety information, verified and peer reviewed by internationally recognised experts. Taking into account advice from manufactures and Poison Control Centres.

http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/intro.htm

Packing Group

Group to which, for packing purposes, certain substances may be assigned in accordance with their degree of danger. The packing groups have the following meaning:

- Packing group I: Substances presenting high danger.
- Packing group II: Substances presenting medium danger.
- Packing group III: Substances presenting low danger.

SEI

Seuil des Effets Irréversibles : "**threshold of irreversible effects**" for a given exposure duration corresponds to the concentration above which irreversible effects may appear in the exposed population.

SEL

Seuil des Effets Létaux : "**threshold of lethal effects**" for a given exposure duration corresponds to the concentration above which mortality can be observed in the exposed population.

SER Seuil des Effets Réversibles : "**threshold of reversible effects**" for a given exposure duration corresponds to the concentration above which reversible effects may appear in the exposed population.

TEEL Acronym for Temporary Emergency Exposure Limit. TEEL numbers are developed by the Subcommittee on Consequence Assessment and Protective Actions (SCAPA), under the U.S. Department of Energy (DOE). Their definitions are as follows:

TEEL-0: The threshold concentration below which most people will experience no appreciable risk of health effects.

TEEL-1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.

TEEL-2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

TEEL-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

The Department of Energy has developed a methodology for deriving temporary emergency exposure limits (TEEL) to serve as temporary guidance until AIHA publishes ERPG concentrations. The TEEL numbers are considered as approximations to ERPGs to be used until the peer-reviewed ERPGs are published.

UN number Four-figure identification number of the substance or article taken from the UN Model Regulations.

Vehicle ID number Unique vehicle identification number per transport automatically generated by the system per substance transported.

Acronyms

AD	Applicable Document.
ADNR	Regulation for the Carriage of dangerous substances on the Rhine.
ADR	European agreement concerning the international carriage of dangerous goods by Road.
AEGL	Acute Exposure Guideline Level
DEI	Data Exchange Infrastructures.
DoW	Description of Work.
EGNOS	European Galileo Navigation Overlay System.
ERPG	Emergency Response Planning Guideline
ESA	European Space Agency.
EU	European Union
GIS	Geographical Information System.
GPS	Global Positioning System.
IDLH	Immediately Dangerous to Life and Health
ISO	International Standards Organisation.
LC1	Lethal Concentration 1%
LC50	Lethal Concentration 50%
LCLo	Lethal Concentration Lowest
MITRA	Monitoring an Intervention for the TRAnsportation of dangerous goods.
OBT	On-Board Terminal.
RD	Reference Document.
RID	Regulation concerning the International carriage of dangerous goods by Rail.
RID	Review Item Discrepancy.
RKP	Risk Knowledge Platform.
SAMUR	Servicio de Asistencia Municipal de Urgencia y Rescate (Medical Service body of Madrid council)
SEI	Seuils des Effets Irréversibles
SEL	Seuils des Effets Létaux
SER	Seuils des Effets Réversibles
SMS	Satellite Mobile System.
STREP	Specific Targeted Research Project
TBD	To be defined.
TEEL	Temporary Exposure Emergency Limits
TN	Technical Note.
VLE	Valeur Limite d'Exposition
VME	Valeur Moyenne d'Exposition
WP	Work-Package.

1 Introduction

1.1 Introduction

The objective of WP2.2 is to organise the available data for effects assessment in case of catastrophic event (characteristics of the chemical products, associated physiological thresholds, types of containers, etc.). These data are necessary for the intervention in case of accident in order to improve the knowledge of the risks of the accidents and the assessment of the potential effects of the accident.

In an accidental situation, it is sometimes difficult for safety services to collect information on the exact nature and the quantity of the material(s) involved and then to quickly determine effect distances. Some databases give distances, generally only one, which do not cover all different situations, in general these distances are determined for the worst case and could be difficult to apply.

MITRA system could allow giving in real time the location of an accidental situation, its nature and the quantity of material(s) involved; thus, via the Risk Knowledge Platform (RKP), it could give two types of information:

- qualitative information (elements of decision-making aid, event trees related to substances transported, datasheet with general effects distances, ..) described in **AD8**,
- quantitative information (effect distances).

This is illustrated on figure 1.

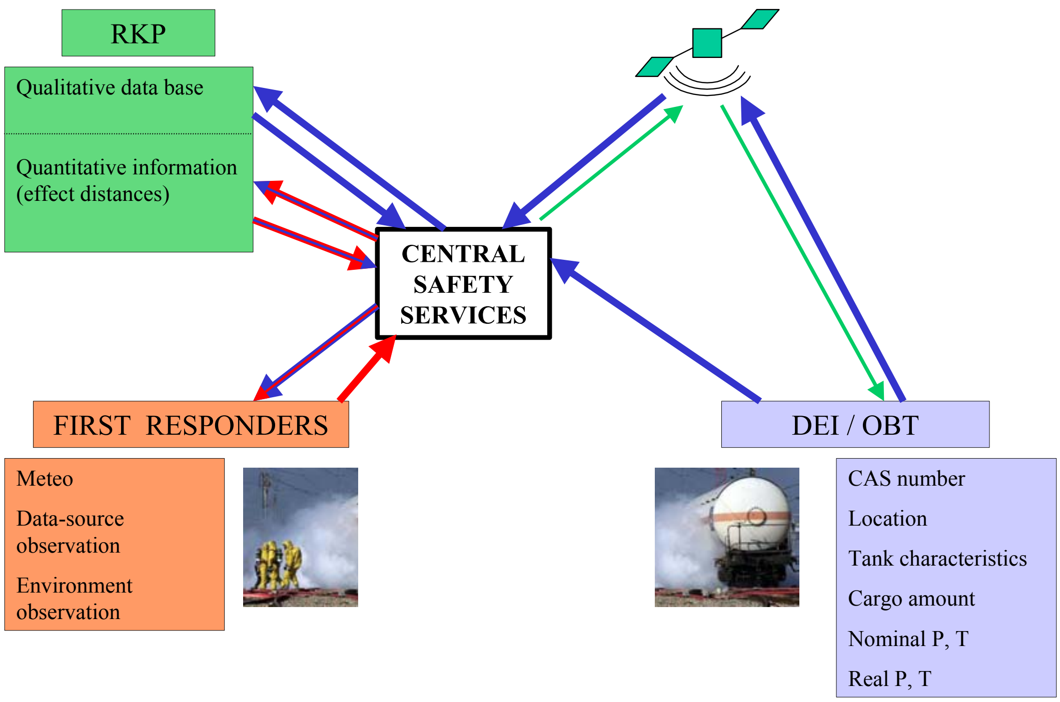


Figure 1: Relation between DEI/OBT, first responders, RKP database, and central safety services

In order to give precise information on effect distances in case of a hazardous material accident, it is necessary to collect information on data-source, environment and atmospheric conditions. The objective of the MITRA system is not to give very precise effect distances, but to give a better order of magnitude than existing databases. The effect distances done by the RKP database could be assessed more accurately in a second time by the classical means of safety services.

Parameters used by models in order to assess effect distances could affect more or less the results. An identification of the important parameters for the models has been made.

In order to quantify these important parameters for the models, we have tried to identify some criteria, which can be easily determined by the first responders on the site of an accident.

The definition of accidental scenarios is based on these simple criteria.

1.2 Purpose and scope of the document

The present document constitutes the deliverable “D2.2: Methodology for consequences assessment” for the MITRA project. This deliverable is a contractual document.

Based on the analysis of past accidents and identification of data to be provided to end-users in case of an accident, WP2.2 aims at defining a methodology to provide end-users with the information necessary to assess the consequences and the risks in case of accident. This methodology takes into account the specificities of effects assessment in France, Spain and Germany.

1.3 Structure of the document

This document is structured as follows:

Section 2 identifies important parameters for the models used in the assessment of the effect distances.

Section 3 gives the modelling parameters.

Section 4 presents the input and output datasheets.

Section 5 describes the algorithm to select one or several specific phenomena linked to an accidental situation.

1.4 Applicable and reference documents

1.4.1 Applicable documents

AD1 TN2.22.1: Chemical’s characterisation, threshold’s definition – ACUTEX project

AD2 TN2.22.2: Chemical’s characterisation, threshold’s definition – Acute toxicity thresholds

AD3 TN2.22.3: Chemical’s characterisation, threshold’s definition – ARAMIS project

AD4 TN2.22.4: Accidental phenomena – thresholds and safety services practices

AD5 TN2.11: Historical analysis of accidents occurred during the transport of hazardous substances by road and rail

AD6 TN2.22.5: Information on selected substances. Thresholds and safety services practices

AD7 TN2.22.6: Datasheet for the definition of accidental scenarios

AD8 TN2.22.7: List and explanation of static information

AD9 D1.2: MITRA Functional Specifications

AD10 D2.1: Analysis of past accidents report

AD11 D3.1: MITRA Architectural Design Document

AD12 TN2.22.8: Accident scenario definition

AD13 TN2.22.9: Algorithm scenario definition

1.4.2 Reference documents

RD1 « Guidelines for chemical transportation risk analysis ». Center for Chemical Process Safety American Institute of Chemical Engineers, 1995.

RD2 Planas, E.; Casal, J. (2004). "Deliverable D2B: Methodology for the calculation of the risk severity index". ARAMIS Projec, EVG1-CT-2001-00036.

2 Important parameters for the models used in the assessment of the effect distances

The assessment of effect distances depends on which phenomena occur when there is an accident of hazardous materials and on which effect we have to work.

For each type of scenario, different types of model exist which depend on the phenomena (fire, atmospheric dispersion, and explosion) and on the effect (thermal, toxic, and overpressure).

In each model used to assess effect distances, we can consider three kinds of parameters: data source, environment, and atmospheric conditions.

The most important ones are indicated hereafter for each kind of these parameters. For each of them, we have indicated from where the input came (DEI/OBT, first responder, or if it is a value chosen by default). Some relevant observation criteria for the first responder are given in annex 3.

2.1 Data source

	Input from :		
	DEI / OBT	**First responder**	**Default value**
Chemicals characteristics	X		
Type of tank	X		
Quantity of chemicals	X		
Storage pressure	X		
Storage temperature	X		
Release conditions: explosion, leak, fire, …		X	
Hole diameter		X	
Pool diameter		X	
Height of breach/tank			X
Height of release			X
Jet direction			X

Table 1: data source parameters

2.2 Environment

	Input from :		
	DEI / OBT	**First responder**	**Default value**
Near field			X
Ground roughness		X	
Topography, obstacles			X

Table 2: Environment parameters

Ground roughness: This parameter represents the small irregularities of the environment of the accident.

2.3 Atmospheric conditions

	Input from :		
	DEI / OBT	**First responder**	**Default value**
Wind speed		X	
Atmospheric stability		X	
Ambient temperature			X
Ground surface temperature			X
Solar flux			X
Air relative humidity			X

Table 3: Atmospheric conditions parameters

2.4 Thresholds

The 18th of May 2005 the four WP2's partners (UPC, COTESA, EMA and INERIS) organised a specific meeting to work on the selection of the hazardous phenomena effects threshold (overpressure, fire, toxicity). The main issue of this meeting is a common approach based on :

- ❒ Existing European projects or European researches related to threshold definition (e.g. ARAMIS, ACUTEX…) ;
- ❒ Existing standards related to threshold definition (US researches …).

2.4.1 Level of effect – ARAMIS feedback

When developing the Risk Severity Index of the ARAMIS project (**AD3 – RD2**), a set of threshold levels have been proposed to be used. The main reason which leads to this new definition was that there was not a uniform criterion all around the European countries in the definition of these levels. Moreover, some countries used the concept of dose while others used maximum values.

The thresholds finally proposed within the ARAMIS project take into account the concept of dose which is more interesting than taking maximum values.

Within the ARAMIS project, four levels of effects were defined.

Level of effect	Description
1	Small or non effects
2	Reversible effects
3	Irreversible effects
4	Start of lethality and/or domino effects

Table 4: Level of effect

Regarding to MITRA objectives (intervention in case of chemical accidents), it is proposed to select only the levels 2 to 4. Because of the deletion of the first one, the levels of effects will be renumbered as follows: level 1: reversible effects, level 2: irreversible effects and level 3: lethal effects.

2.4.2 Thresholds related to Radiation and Blast

According to TN2.22.3. "Chemical's characterisation, thresholds definition – ARAMIS Project thresholds » (**AD3**), the first proposition consisted on selecting these thresholds, which are renumbered in the scope of MITRA project as follows:

Level of effects	Radiation(1) (kW/m^2)	Instantaneous Radiation	Blast (mbar)	Description
1	1,8		30	Reversible effects
2	3		50	Irreversible effects
3	5	0,5 LFL	140	Start of lethality and/or domino effects

(1) For time exposure equal or greater than 60 s

Table 5: Definition of the thresholds for the diverse levels of effects considered within the MITRA project.

Concerning radiation thresholds, it is widely accepted that the radiation dose can be obtained from Eq. 1:

$$Dose = q^{4/3} \cdot t \qquad \textbf{Eq. 1}$$

Where

q thermal radiation, W/m^2

t exposition time, s

The level of effect is characterized by a given radiation dose (radiation value for a given period of time). Thus, in the case of a non-stationary radiation effect –as in a fireball- what should be computed is the total dose received at a given distance (according to the duration of the fireball) and this dose should be compared with those given as threshold levels.

As an example, suppose that at a given distance *d* of a fireball a constant thermal radiation of 7000 W/m^2 is received and that the duration of the fireball is 40 seconds. At this distance the dose which will be received is 5356207 (W/m^2)$^{4/3}$·s. This dose is equivalent to a radiation of 5165 W/m^2 during 60 s, and comparing it to the levels of effects for radiation, this corresponds to the level 4.

2.4.3 Thresholds related to Acute toxicity

In regards to the acute toxicity threshold European harmonisation, a first approach is developed in the ACUTEX project, which is a shared-cost action funded under the European Union's Fifth Framework programme of Research.

ACUTEX is intended to develop a methodology and guidelines for establishing European acute exposure levels that allows for sharing of common scientific data and common principles of extrapolation among Member States. It is expected that the project will create a complementary system to the US AEGLs program that also meets needs specific to European users.

However, it still does not exist European Acute Toxicity Threshold related to the nine chemical substances selected in MITRA project (**AD10**).

In addition, each country has its own criteria to assess chemical risk in emergency:

- By using different numerical models to simulate a toxic release: e.g. in Spain, UPC uses Effects of the TNO, in France INERIS uses PHAST of DNV or specific models, and EMA uses it's own models ;
- By using different acute toxicity threshold: e.g. in Spain, UPC uses TEELs, … , in France INERIS and EMA use "French" threshold (see annex 1: French approach, and annex 2: US approach).

In spite of all this conditionings, the approach uses in MITRA project is directed towards the use of SER, SEL and SEI thresholds (the French ones), or in case of lack of data, the use of:

- Firstly: AEGL1, AEGL2 and AEGL3,
- Secondly: ERPG1, ERPG2 and ERPG3,
- Thirdly: TEEL1, TEEL2 and TEEL3.

This threshold selection procedure should be also followed not only in the MITRA prototype system, but also in the real application if this is the case.

2.4.4 Case Study

One of the first issues (AD10) of WP2.1 (lessons learned from past accidents) is the selection of nine chemical substances used to implement the Risk Knowledge Platform:

Chemical Substance	ONU Class
Ammonium Nitrate	1 & 5
LPG (propane)	2
Chlorine	2
Hydrocarbon Liquid (gasoline)	3
Acrylonitrile	3
Phosphorus	4
Aluminum	4
Hydrogen Peroxide	5
Ammonia	6

Table 6: Thresholds for the substances selected in MITRA prototype.

Thus, the thresholds in the following table for the acute toxic substances included in the previous selected group of nine substances will be used.

Substance	Reversible effects		Irreversible effects		Lethal effects	
	30 min	60 min	30 min	60 min	30 min	60 min
Acrlylonitrile	10 (c)	10 (c)	37 (a)	22 (a)	236 (a)	139 (a)
(n =)	-	-	*1.32*	*1.32*	*1.32*	*1.32*
Ammonia	30 (b)	30 (b)	500 (a)	354 (a)	4767 (a)	3400 (a)
(n =)	-	-	*2.00*	*2.00*	*2.03*	*2.03*
Chlorine	0.5 (b)	0.5 (b)	25 (a)	19 (a)	160 (a)	110 (a)
(n =)	-	-	*2.30*	*2.30*	*1.98*	*1.98*

(a): French thresholds
(b): AEGL thresholds
(c): ERPG thresholds
(d): TEEL thresholds

Table 7: Thresholds for the substances selected in MITRA prototype.

Nevertheless, for the final MITRA application, it is necessary to have some recognised European thresholds, in accordance with European projects in progress (ACUTEX, …).

3 Modelling parameters

All the parameters needed for models should be defined in order to select a set of fixed scenarios to be modelled. In the next table, the majority of the parameters needed for models are defined as well as their declared values.

	Parameters	Parameter value(s)					
1	Type of tank	Road tank		Rail tank			
2	Quantity of chemicals	Full tank					
3	Storage pressure	Saturated vapour pressure					
4	Storage temperature	20°C					
5	Release conditions	Catastrophic rupture		Leak : 2 inch diameter		Leak : ½ inch diameter	
6	Height of breach/tank (see fig. 2)	0 m					
7	Height of release/ground (see fig. 2)	1 m					
8	Jet direction	Horizontal					
9	Pool diameter	3 m		10 m		Maximum diameter	
10	Near field	Free jet					
11	Topography, obstacles	Flat, none					
12	Ground roughness	"Open country" (3 cm)		"Urban or forest" (100 cm)			
13	Atmospheric conditions (Pasquill stability class – wind speed)	B - 3 m/s	C - 3 m/s	C - 5 m/s	D - 5 m/s	E - 2 m/s	F - 3 m/s
14	Ambient temperature	20°C				15°C	
15	Ground surface temperature	20°C					
16	Air relative humidity	70%					
17	Solar flux	500 W/m^2					
18	Toxic exposure duration	30 min		60 min			

Table 8: parameter values for numerical simulations

No specific topography and no obstacles with dimensions of the order of magnitude of the toxic cloud are taken into account in this study. All calculations are made over flat homogeneous surface.

Some parameters could be also added if necessary.

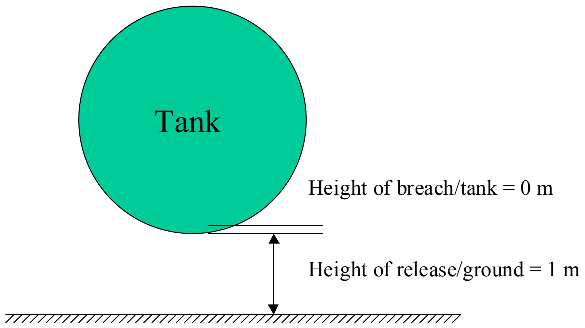


Figure 2: Description of parameters 6 and 7

As previously stated in the document TN 2.22.6: “Datasheet for the definition of the accidental scenarios - Descriptions, casuistry and reflections for future work” (22/04/2005, UPC)” (**AD7**), the modelling parameters considered above plus the different types of transport concerning each substance, would give a huge number of scenarios to consider, which is impossible to cover by the project. In order to study the most significant cases of all the casuistry, it is agreed to consider only atmospheric conditions (F - 3 m/s for night accidents) and (D - 5 m/s for day accidents) in the scenarios concerning toxic releases. Nevertheless, in a real implementation of MITRA system, the casuistry collected in the following figure should be considered.

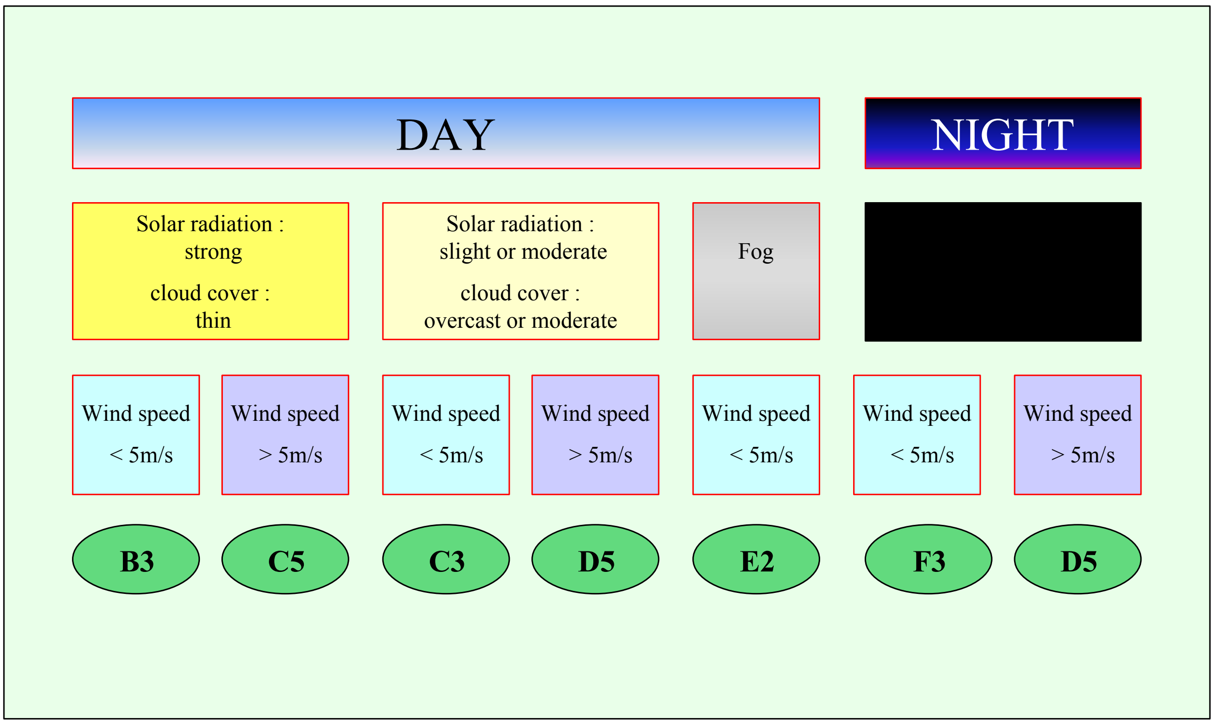


Figure 3: Atmospheric conditions assessment

This figure follows the Pasquill rules as shown in Table 10 (annex 3).

4 Result datasheet

A common datasheet for WP2 partners is presented in the following Figure 4 and Figure 5.

All partners involved in the modelling process, in order to harmonise the final results of this step and to facilitate their implementation should use this common datasheet

The inputs collected in the scenario datasheet are organised by different sections, which are described as follows:

The first one contains **general information,** as the title of the scenario (which shall be the name of the substance followed by an ordinal number), and the scenario description (which shall include a brief text containing the information related to the casuistry concerning the certain scenario).

The second one refers to the basic **substance information** necessary to do the modelling (CAS number, toxic thresholds in case of toxic substance and main hazards to take into account.)

The third one involves the information needed for **transport conditions**: type of tank, pressure and temperature and, the most important, quantity. This last parameter will be always considered as the full tank (being coherent with the second parameter of the table 11). It should be highlighted that there exists different types of transport among the nine selected substances, and all of them should be simulated.

The fourth refers to the **environment**, to the ground roughness to be precise. Only two options shall be considered in the modelling process: 3cm or 100 cm roughness.

The fifth contains the **meteorological conditions**. One parameter is fixed (relative humidity), and the others must be selected among the options presented. Nevertheless, as agreed and explained before, only two cases of stability class/wind speed shall be considered during the coming modelling process: (D – 5 m/s) and (F – 3 m/s). However, the table created actually considers more options, as it may be used in a real application of MITRA system.

The group of parameters (3d, 4th and 5th) shall generate all the casuistry of the substance. That is, if a substance presents 2 different modes of transport, the total number of scenarios to consider for simulation purposes will be:

2 modes of transport x 2 different roughness x 2 different stability classes = 8 scenarios.

Finally, the second part of the input datasheet is grouped by means of two sections, the first one concerning **event tree results**, which shall determine the general accidental event (or events) derived from a certain substance and the latter which shall contain the specific **event modelled**. A strong effort has been made in order to compile all the origins that the different accidental events may have.

Concerning the output datasheet (Figure 6), it contains three different sections to compile the results of the overpressure effect distances, thermal effect distances and toxic effect distances.

To finalise this approach, these datasheets have to be completed by algorithms to select one or several specific phenomena linked to an accidental situation. This step is described in the part 5.

GENERAL INFORMATION

Title of the scenario	
Scenario description	

SUBSTANCE INFORMATION

CAS number	

Toxic thresholds

Level	*Value*	*Type*
Reversible		
Irreversible		
Lethal		

Main hazards	

TRANSPORT CONDITIONS

Type of tank		
Pressure (bar)		
Temperature (K)		
Quantity (kg)		*(Full tank)*

ENVIRONMENT

Ground roughness

Open country (3 cm)	
Urban or forest (100 cm)	

(select one of the two options)

METEOROLOGY

Relative humidity (%)	70

Atmospheric conditions

B - 3 m/s - 293K	
C - 3 m/s - 293K	
C - 5 m/s - 293K	
D - 5 m/s - 293K	
E - 2 m/s - 288K	
D - 5 m/s - 288K	
F - 3 m/s - 288K	

(select one of the seven options)

Figure 4 : First part of the datasheet for inputs modelling parameters

EVENT TREE RESULTS

	Yes	*No*
Physical Explosion		
BLEVE		
Fireball		
Jet fire		
Pool fire		
Toxic cloud		
Flash fire		
Vapor Cloud Explosion		

(select the corresponding options)

EVENT MODELIZED

(select the applicable options from the following list)

Overpressure effects

Container Physical Explosion	
BLEVE	
Vapor cloud explosion (pool 3m)	
Vapor cloud explosion (pool 10m)	
Vapor cloud explosion(pool max diam)	
Vapor cloud explosion (1/2 inch hole diam, vapor leak)	
Vapor cloud explosion (2 inch hole diam, vapor leak)	
Vapor cloud explosion (catastrophic rupture, vapor leak)	

Thermal effects

Fireball	
Small jet fire (1/2 inch hole diam)	
Large jet fire (2 inch hole diam)	
Small pool fire (3 m diam)	
Medium pool fire (10 m diam)	
Large pool fire (max diam)	
Flash fire cloud (pool 3m)	
Flash fire cloud (pool 10m)	
Flash fire cloud (pool max diam)	
Flash fire cloud (1/2 inch hole diam, vapor leak)	
Flash fire cloud (2 inch hole diam, vapor leak)	
Flash fire cloud (catastrophic rupture, vapor leak)	

Toxic effects

Toxic cloud (pool 3m)	
Toxic cloud (pool 10m)	
Toxic cloud (pool max diam)	
Toxic cloud (1/2 inch hole diam, vapor leak)	
Toxic cloud (2 inch hole diam, vapor leak)	
Toxic cloud (catastrophic rupture, vapor leak)	

Figure 5: Second part of the datasheet for inputs modelling parameters

DISTANCES (m)

(Fill the selected modelized events)

OVERPRESSURE EFFECTS

	Rev.	Irrev.	Lethal
Container Physical Explosion			
BLEVE			
Vapor cloud explosion (pool 3m)			
Vapor cloud explosion (pool 10m)			
Vapor cloud explosion(pool max diam)			
Vapor cloud explosion (1/2 inch hole diam, vapor leak)			
Vapor cloud explosion (2 inch hole diam, vapor leak)			
Vapor cloud explosion (catastrophic rupture)			

THERMAL EFFECTS

	Rev.	Irrev.	Lethal
Fireball			
Small jet fire (1/2 inch hole diam)			
Large jet fire (2 inch hole diam)			
Small pool fire (3 m diam)			
Medium pool fire (10 m diam)			
Large pool fire (max diam)			
Flash fire (pool 3m)			
Flash fire (pool 10m)			
Flash fire (pool max diam)			
Flash fire (1/2 inch hole diam, vapor leak)			
Flash fire (2 inch hole diam, vapor leak)			
Flash fire (catastrophic rupture)			

TOXIC EFFECTS

	30 min			60 min		
	Rev.	Irrev.	Lethal	Rev.	Irrev.	Lethal
Toxic cloud (pool 3m)						
Toxic cloud (pool 10m)						
Toxic cloud (pool max diam)						
Toxic cloud (1/2 inch hole diam, vapor leak)						
Toxic cloud (2 inch hole diam, vapor leak)						
Toxic cloud (catastrophic rupture, vapor leak)						

Figure 6: Datasheet for output modelling results

5 Algorithms to select a specific phenomena

A set of input data (first responders, OBT,…) are defined in previous documents, and a proposed set output data has been defined. The objective of the six algorithms is to clearly identify a phenomenon according to environmental data (input data) in order to precise output data. To reach this goal, six algorithms have been developed:

- the first one, concerns the specification of the tank characteristics

- the second one, allows to define the environmental and atmospheric conditions

- the third one is dedicated to the selection of a or several phenomena (pool, leak, container exposed to fire or container destroyed)

- the three last, called respectively pool, leak and container, describe the way to obtain specific phenomena like for example BLEVE, UVCE or Toxic cloud.

The result is one or more specific phenomena, so the end users obtain one set of distances by specific phenomena selected.

5.1 Methodology to select a specific phenomena

The six algorithms described in this document allow selecting one or several specific phenomena link to an accidental situation. The way to use them is the following:

- first, the tank characteristics must be defined (see tank characteristics algorithm)
- second, the environmental and atmospheric conditions have to be assessed (see environmental and atmospheric conditions algorithm)
- third, the phenomena observed must be identified (see scenario 1 algorithm)
- fourth, one or several specific phenomena must be selected in function of identified phenomena of the previous step (see pool, leak and container algorithms)

To read, the algorithms:

- the blue box is relative to On Board Terminal (OBT) information
- the green box is relative to question asked to the first responders
- the yellow box is relative to the answers
- the orange box is relative to a result.

The final part of this document presents all the proposed algorithms.

5.2 Tank characteristics algorithm

The following algorithm is used to define the Tank characteristics (figure 7).

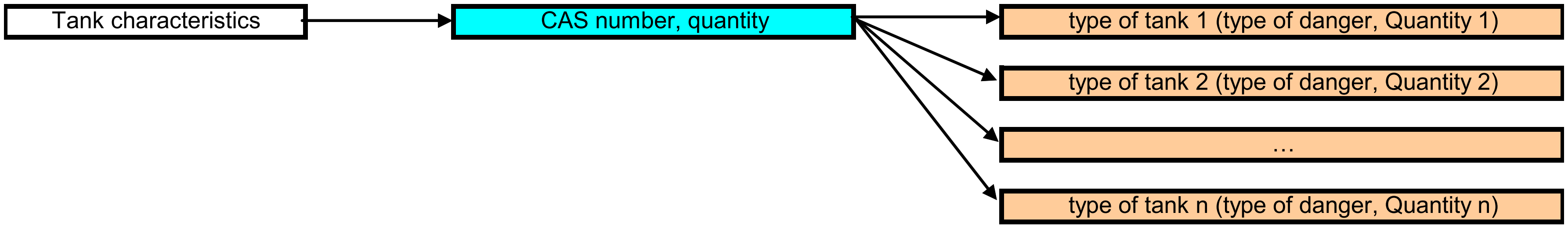


Figure 7: Tank characteristics algorithm

The result is a set of information to specify the CAS number and the quantity of a specific substance. The type of danger corresponds to flammable and toxic properties of the substance. The pressure and the temperature can be also added but they are not included in the MITRA prototype.

5.3 Environmental and atmospheric conditions (EAC) algorithm

The algorithm is used to define the environmental and atmospheric conditions (figure 8)

By the use of the Environmental and Atmospheric Conditions algorithm, the user must specify:

- the roughness of the territory: 2 types of roughness are available, an urban, industrial or forest one or an open countries one.
- The atmospheric conditions by the evaluation of the stability class and an ambient temperature. To evaluate the stability class, user must assess the cloud cover and the wind speed of the location of hazardous transportation accident. For the ambient temperature, two types of temperature are selected in the Risk Knowledge Platform (RKP) which have been chosen as representative values.

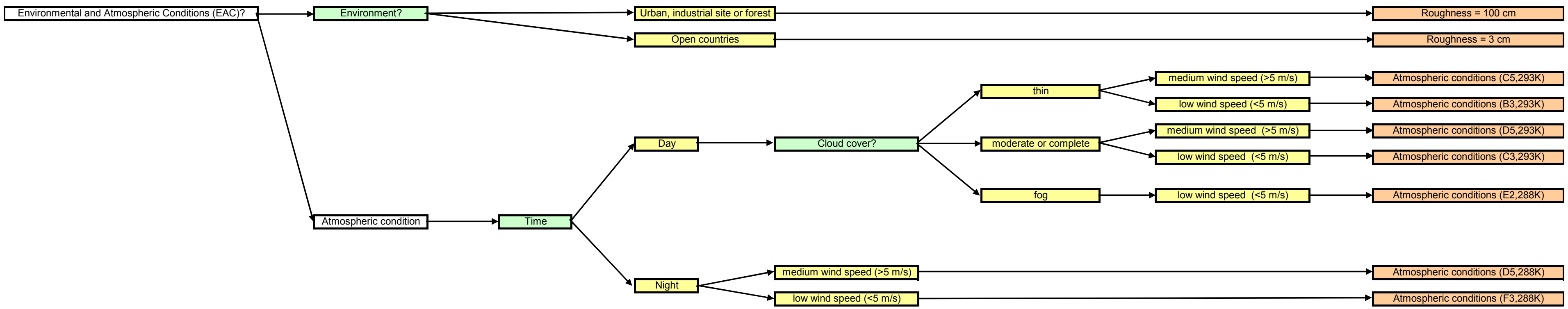


Figure 8: Environmental and atmospheric conditions

The result is a set of information to specify the stability class, the wind speed, the roughness and the temperature of a specific situation.

5.4 Phenomena algorithm

The algorithm is used to define the phenomena (figure 9).
By the use of the Phenomena algorithm, the users obtain the possible type of phenomena due to the hazardous transportation accident. Three main phenomena are a leak, a pool or the container exposed to fire or container destroyed

By the use of simple evidence from a witness of the accident or a first responder, this algorithm allows to specify one phenomena or several which realised or which could be generated. For each type of phenomena a specific algorithm has been developed.

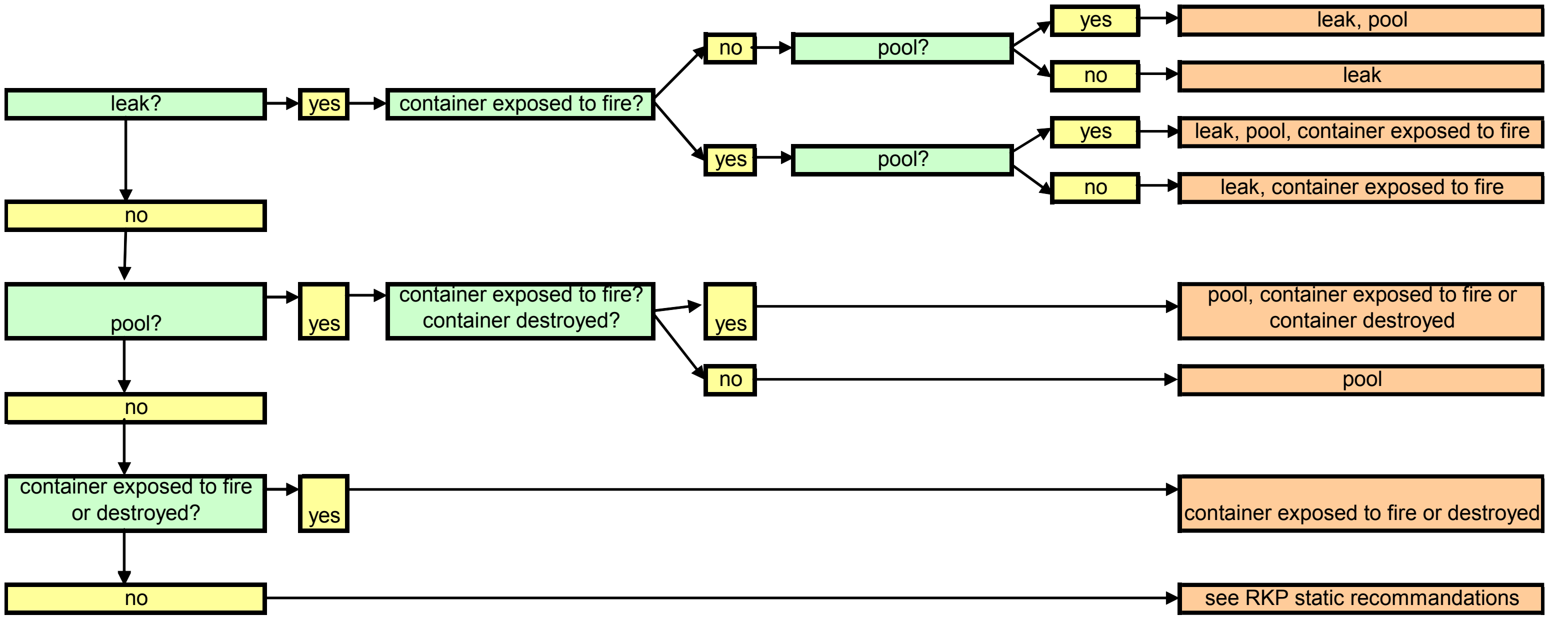
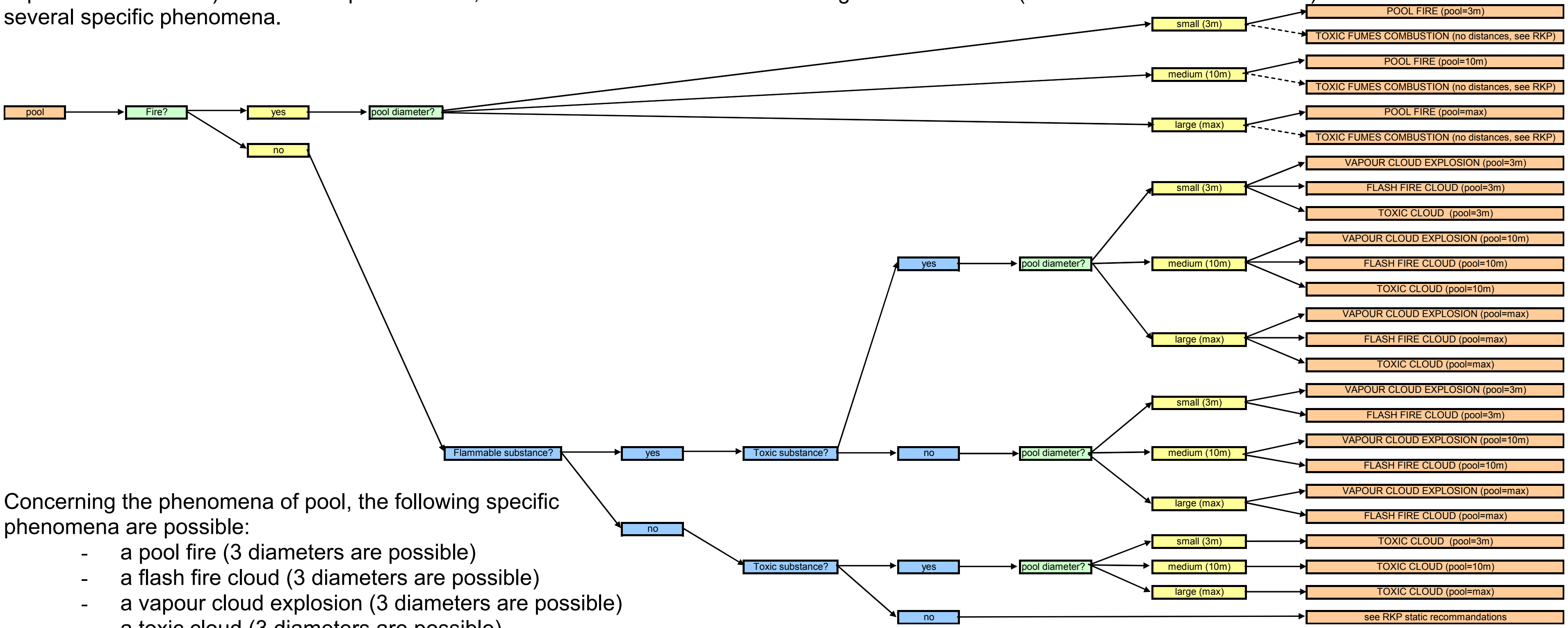


Figure 9: Phenomena algorithm

The result is a set of information to specify the type of phenomena of a specific situation.

5.5 Pool algorithm

The algorithm is used to define the specific phenomena link to the pool (figure 10). The witness or first responder has put forwards the formation of a pool of dangerous substance. The user must know two information “Is there a pool fire?” and the area of pool (small about 3 meters, medium about 10 meters and large superior at 10 meters). With the help of the RKP, the main risks associated to the dangerous substance (flammable or toxic substance) are used to select one or several specific phenomena.



Concerning the phenomena of pool, the following specific phenomena are possible:

- a pool fire (3 diameters are possible)
- a flash fire cloud (3 diameters are possible)
- a vapour cloud explosion (3 diameters are possible)
- a toxic cloud (3 diameters are possible)
- and a toxic fumes combustion.

Figure 10: Pool algorithm

The result is a set of information to specify the specific phenomena of a specific situation due to a pool.

5.6 Leak algorithm

The algorithm is used to define the specific phenomena link to the leak (figure 11)

The witness or first responder has put forwards a leak of dangerous substance. The user must know two information "Is there a fire?" and the breach size (small about ½ inch, large about 2 inch). With the help of the RKP, the main risks associated to the dangerous substance(flammable or toxic substance) are used to select one or several specific phenomena.

Concerning the phenomena of leak, the following specific phenomena are possible:

- a jet fire (small or large)
- a flash fire cloud (2 breach sizes are possible)
- a vapour cloud explosion (2 breach sizes are possible)
- a toxic cloud (2 breach sizes are possible)

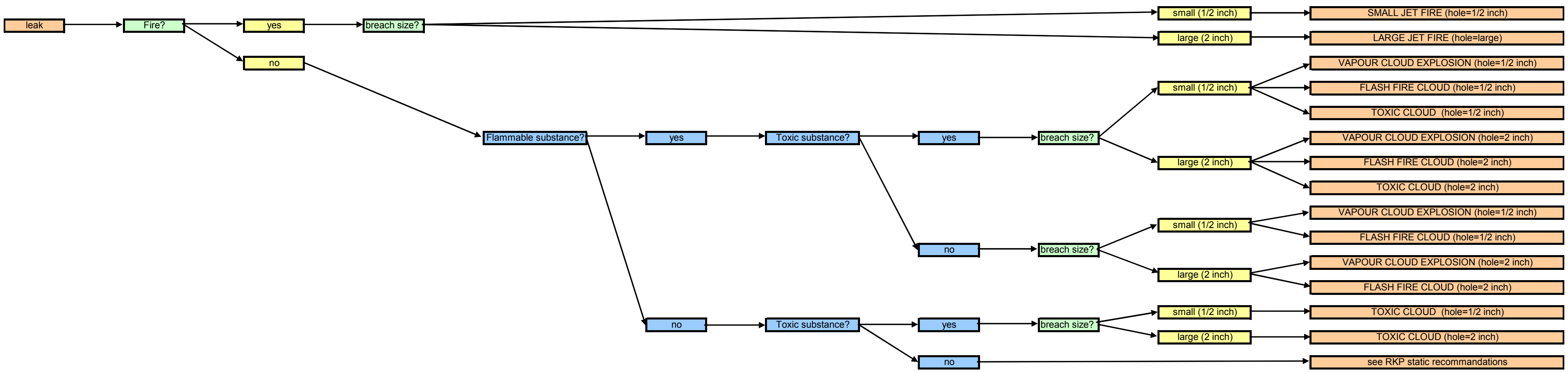


Figure 11: Leak algorithm

The result is a set of information to specify the specific phenomena of a specific situation due to a leak.

5.7 Container algorithm

The algorithm is used to define the specific phenomena link to a container exposed to fire or destroyed (figure 12).

The witness or first responder has put forwards a container exposed to fire or a container destroyed. With the help of the RKP, the main risks associated to the dangerous substance (flammable or toxic substance) are used to select one or several specific phenomena.

Concerning the phenomena of container exposed to fire or container destroyed, the following specific phenomena are possible:

- a container physical explosion
- a flash fire cloud (catastrophic rupture)
- a vapour cloud explosion (catastrophic rupture)
- a toxic cloud (catastrophic rupture)
- a Boiling Liquid Expanding Vapor Explosion (BLEVE) or Fireball

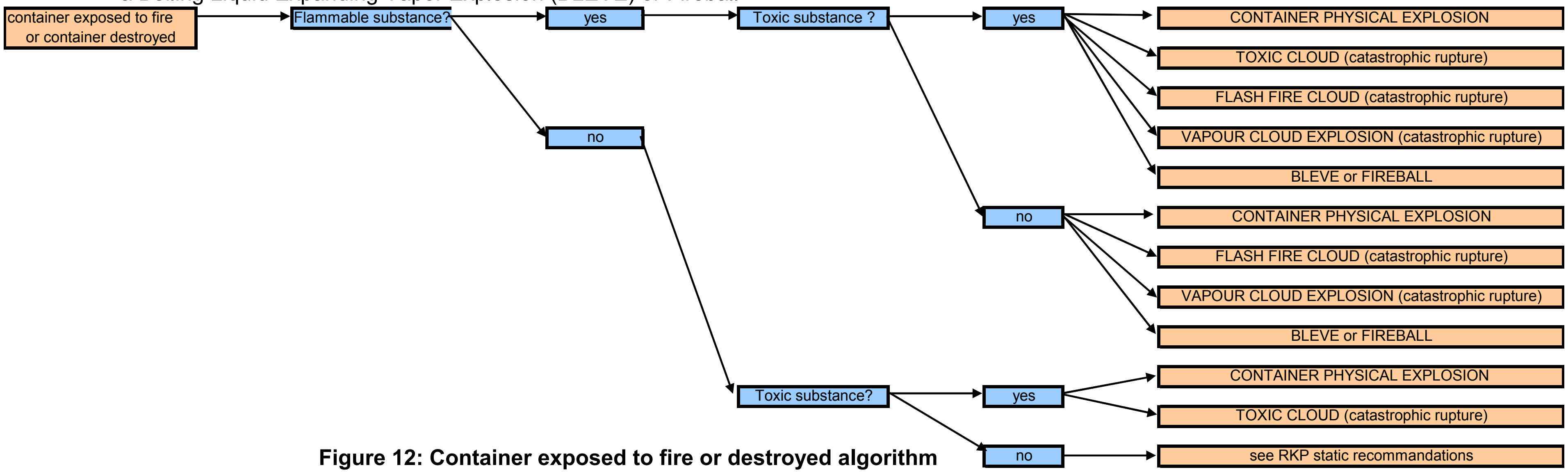


Figure 12: Container exposed to fire or destroyed algorithm

The result is a set of information to specify the specific phenomena of a specific situation due to a container exposed to fire or a destroyed.

When a specific phenomena is selected, with the "tank characteristics" and "environmental and atmospheric conditions" determined, the RKP must provided a set of distances (reversible, irreversible and lethal effect distances) for the effect generated by the specific phenomena (overpressure, thermal radiation or toxic effects).

6 First Conclusions

The WP2.2's objective aims at establishing a methodology to assess the effects of hazardous goods transport accident to provide relevant information (e.g. safety distances…) in real time.

This deliverable describes an approach to get this objective and scopes on the important parameters for the models used in effects distances assessment, the datasheet and the algorithm to select the specific phenomena.

The next step is to make numerical simulation in order to implement the RKP.

In this framework, each partner will use its own tools to simulate the accident scenarios. The substances to simulate by each partner will be:

- UPC: chlorine, LPG and gasoline
- EMA: Chlorine, Ammonia and Hydrogen peroxide
- INERIS: Acrylonitrile, Ammonium nitrate and chlorine

7 List of annex

- Annex 1: French approach on selecting acute toxicity thresholds
- Annex 2: US approach on selecting acute toxicity thresholds
- Annex 3: Relevant observation criteria for first responder inputs

7.1 Annex 1: French approach .

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MINISTÈRE DE L'

L'ECOLOGIE ET DU DÉVELOPPEMENT DURABLE

DIRECTION DE LA PREVENTION

DES POLLUTIONS ET DES RISQUES

Service de *l'Environnement Industriel*

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Objet:

Détermination de seuils de toxicité aiguë de substances dangereuses

Mesdames, Messieurs,

La publication intitulée « Fiches Techniques / Courbes de toxicité aiguë par inhalation» éditée en juin 1998 par mon service présente les seuils d'effets létaux et des seuils d'effets irréversibles de 26 substances dangereuses. Ces seuils peuvent être appliqués dans le cadre de l'évaluation des risques lorsque les scénarios d'accident mettent en œuvre une émission accidentelle de substances dangereuses,

Compte tenu de l'incertitude liée à certaines valeurs présentées dans le guide de 1998, les fiches de toxicité aiguë sont actuellement en cours de révision par l'INERIS à la demande du ministère, Les nouveaux seuils proposés sont élaborés sur la base d'une méthodologie disponible sur le site internet de l'INERIS, Pour chaque substance, la réactualisation des seuils fait l'objet d'un rapport présentant notamment l'ensemble des données bibliographiques disponibles et utilisées pour déterminer seuils d'effets létaux et des seuils d'effets irréversibles. Ces rapports sont validés par un groupe de consensus associant des représentants de l'administration, des industriels, et des experts toxicologues, .

L'intégralité du guide de 1998 devrait être révisée d'ici 2005, D'ores et déjà, vous pouvez avoir accès sur internet aux rapports relatifs aux substances suivantes:

chlorure de vinyle; phosgène; ammoniac;

acide chlorhydrique; hydrogène sulfuré; acide fluorhydrique; chlore.

Les nouvelles valeurs remplacent celles de 1998. D'ici fin 2003, les seuils relatifs à l'acryloniltrile, l'acide cyanhydrique, le trifluorure de bore, la méthamine, le styrène, le formol, l'hydrazine, le diooxyde de souffre, le monoxyde d'azote, le dioxyde d'azote et le 2,4 diisocyanate de toluène. Aussi, je vous invite à consulter régulièrement le site de l'INERIS afin de vous informer des seuils réactualisés.

Dans l'attente des nouveaux seuils, les valeurs de 1998 peuvent servir de référence.

Lorsqu'ils sont définis pour une substance donnée, les seuil s de toxicité aiguë SEI et SEL doivent être retenus dans les études de dangers et se substituent aux valeurs IDLH (Immediately Dangerous to Life or Health). .

Dans le cas où les Seuils d'Effets Irréversibles (SEI) et les Seuils d'Effets Létaux (SEL) ne sont pas disponibles pour une substance donnée, les valeurs Niosh Pocket doivent être utilisées.

Le choix entre les valeurs Niosh Pocket de 1987 et celles de 1994/95 doit être fondé sur lé pertinence des valeurs et justifié par l'exploitant ou le tiers expert, Ce choix est donc spécifique de la substance concernée. La présente position constitue une évolution de la position du ministère datant 1995 où seules les valeurs de Niosh Pocket de 1987 étaient préconisées.

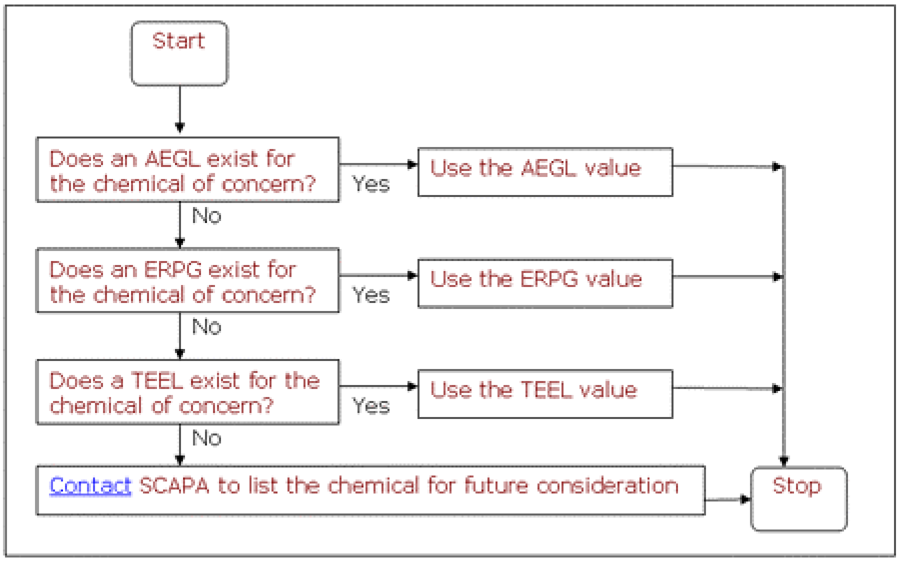
Le chef du Service de l'Environnement Industriel

Marie-Claude DUPUIS

7.2 Annex 2: US approach .

See http://www.orau.gov/emi/scapa/teels.htm

The following flowchart illustrates the process for determining which value is to be used in an assessment.



References:

"No ERPG? Use a TEEL!" (from DOE Emergency Manager, Oct. 1998). This article provides an explanation on how ERPGs and TEELs are used in DOE Emergency Planning.

"Methodology for Deriving Temporary Emergency Exposure Limits (TEELs)" provides documentation on how TEELs are derived. *This guidance was first published in "Alternative Guideline Limits for Chemicals Without ERPGs," Craig, D.K., Davis J.S., DeVore, R. , Hansen, D.J., Petrocchi, A.J., Powell, T.J., American Industrial Hygiene Association Journal, 56:919-925 (1995).*

7.3 Annex 3: Relevant observation criteria for first responder inputs

To determine quantitative information, some of the necessary RKP inputs must be given by the **first responders**.

Concerning atmospheric conditions, some links between weather conditions (wind velocity, Pasquill stability classes) and in situ observations can be found in the following tables (Table 9 and Table 10). Moreover, some indications like those given in Table 11 may help in estimating an order of magnitude for the roughness length.

It should be mentioned that this information collected in the following tables is in fact not necessary for the modelling methodology, but for the first responder and for the operator in order to easily and clearly define the accidental scenario by means on the questionnaire presented in the Table 12.

BEAUFORT SCALE: Specifications and equivalent speeds for use on land

Force	Wind speed 10m above ground		Description	Specifications for use on land
	m/s	km/h		
0	< 0.3	< 1	Calm	Calm; smoke rises vertically.
1	0.3-1.5	1-5	Light air	Direction of wind shown by smoke drift, but not by wind vanes.
2	1.5-3	6-11	Light Breeze	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
3	3-5	12-19	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag.
4	5-8	20-28	Moderate Breeze	Raises dust and loose paper; small branches are moved.
5	8-11	29-38	Fresh Breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	11-14	39-49	Strong Breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	14-17	50-61	Near Gale	Whole trees in motion; inconvenience felt when walking against the wind.
8	17-21	62-74	Gale	Breaks twigs off trees; generally impedes progress.
9	21-24	75-88	Severe Gale	Slight structural damage occurs (chimney-pots and slates removed).
10	24-28	89-102	Storm	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
11	28-33	103-117	Violent Storm	Very rarely experienced; accompanied by wide-spread damage.
12 and >	> 33	> 117	Hurricane	--

Table 9: Beaufort scale for use on land (from the British Met Office, http://www.met-office.gov.uk/education/curriculum/lesson_plans/weatherobserving/partc.html)

Wind speed	Day: solar radiation			Night: cloud cover		
(m/s)	Strong	Moderate	Slight	Thin	Moderate	Overcast
< 2	A	A-B	B	-	-	D
2-**3**	A-B	B	C	E	**F**	D
3-5	**B**	B-**C**	C	D	E	D
5-6	**C**	C-**D**	D	D	**D**	D
> 6	C	D	D	D	D	D

Table 10: Weather conditions and Pasquill classes (from PHAST user's guide, modified from Pasquill & Smith, 1983)

Roughness Length (cm)	Landscape type
0.02	Water surface
0.24	Completely open terrain with a smooth surface, e.g.concrete runways in airports, mowed grass, etc.
3	Open agricultural area without fences and hedgerows and very scattered buildings. Only softly rounded hills
5.5	Agricultural land with some houses and 8 metre tall sheltering hedgerows with a distance of approx. 1250 metres
10	Agricultural land with some houses and 8 metre tall sheltering hedgerows with a distance of approx. 500 metres
20	Agricultural land with many houses, shrubs and plants, or 8 metre tall sheltering hedgerows with a distance of approx. 250 metres
40	Villages, small towns, agricultural land with many or tall sheltering hedgerows, forests and very rough and uneven terrain
80	Larger cities with tall buildings
160	Very large cities with tall buildings and skyscrapers

Table 11: Surface roughness lengths - Definitions according to the European Wind Atlas, WAsP (Troen & Petersen, 1991)

In order to define how significant parameters could be estimated by an emergency service, from in situ observations, we have tried to identify some criteria that can be easily determined according to a **set of simple selected questions** (which can be answered without sophisticated measuring instruments, but with the tables mentioned above) for each kind of parameters: data-source, environment and atmospheric conditions.

Data source				
Has an explosion occurred?	No	Yes		
Is there a fire?	No	Yes		
Is there a leak? - Can you smell anything? - Can you see any cloud? - Can you hear anything? - Can you see a hole?	No	Small[1]?	large	
Is there a pool?	No	Small (diameter < 3 m)	Medium (diameter < 10 m)	Large (diameter > 10 m)
Environment				
Roughness Is there a lot of trees? houses?, Is an industrial or rural site?	"Open country"	"Urban, industrial site or forest"		
Atmospheric conditions				
Time	Day	Night		
Cloud cover	No clouds	Partly	Complete	
Wind speed	Low (< 5 m/s) (< 20 km/h)	Medium (> 5 m/s) (> 20 km/h)		

Table 12: Set of simple selected questions for first responder

Referring the roughness, it could be considered that the first six rows of the Table 11 are represented as "open country", which means a roughness of 3 cm, and the following three ones are represented as "urban, industrial or forest", which means a roughness of 100 cm.

A similar consideration could be done with the Table 9. That is, the Force below 4 of the Beaufort scale could be considered as "low wind" whereas the Force greater than 4 could be considered as "medium wind".

[1] The term "small" referred to a leak must be revised with TN containing the small leakage considerations