Contract n° : NMP2-CT-2003-505555

S H A P E – R I S K

SHARING EXPERIENCE ON RISK MANAGEMENT (HEALTH, SAFETY AND ENVIRONMENT) TO DESIGN FUTURE INDUSTRIAL SYSTEMS

Co-ordination Action

Priority 3 : **Nano-technologies and nano-sciences, knowledge-based multifunctional materials, and new production processes and devices – 'NMP'**

Deliverable D 10 (D.2.C)

Synthesis document on WP 2

Due date of deliverable : **February 28th 2005**
Actual submission date : **February 28th 2005**

Start date of project : **01.03.2004** Duration : **3 years**

Author : Ingrid HEIDEBRINK – TNO (WP 2 leader), Johan REINDERS – TNO, in close cooperation with the partners in the WP2 project.

Version n°2

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission services)	

Reference Workpackage(s)

WP 2	Continuity of risk management from work place accident to major accident

Version history

v1	draft	21/02/2005
v2	final	25/03/2005

Abstract

Work package 2 deals with the continuity of risk management from workplace accident to major accident. The coordination action shows a large variety in methods and criteria used as well as institutions involved in the various countries that have been studied, all with their own specific pros and cons regarding the possibilities for integrating occupational and external risk management. In some countries the safety management system is seen as providing a link between occupational accidents and major accidents.

The three main obstructions regarding integration of occupational and external risk management concern the definition of the term major accident, the different competent authorities and the different methods to assess both types of risks. Firstly in the SEVESO Directive there appears to be lack of clarity about the definition of major accident where it speaks about a serious danger inside or outside the establishment. In most countries inside dangers are not taken into account in the reports in the framework of the SEVESO legislation. Secondly in nearly all countries involved in this survey, occupational safety and external safety are dealt with by different organisations. Thirdly the methods to determine the occupational and external risks are not harmonised. The recommendations do focus on the remediation of the three main obstructions. For the industry an integrated approach of occupational and external risks may have the advantage of a smaller administrative overhead, lower costs and shorter permission time.

INERIS quality approval :

	Verified by	**Verified by**	**Approved by**
Name	Christophe BOLVIN	Oliver SALVI	Bruno FAUCHER
Title	Engineer Accidental Risk Division	Scientific Officer Accidental Risk Division	Director Accidental Risk Division
Signature			

Table of contents

1. Introduction

The SHAPE RISK Work package 2 project deals with: the continuity of risk management from workplace accident to major accident. The objectives of WP2 are the following:

- To create networking and experience sharing opportunities within the scientific organisations giving technical support to the Competent Authorities and the other stakeholders concerned by the topic
- To identify the existing key information and knowledge on the topic, and describe the state of the art
- To identify the needs for future RTD activities addressing the global objective to reduce risks in production, storage and manufacturing
- To facilitate transversal dialogue between experts, Competent Authorities and other stakeholders

The scope of interest is companies producing, processing, handling, storing or transporting (or combinations thereof) 'chemical' substances: i.e. the chemical process industry, refineries, tanker parks, chemical products warehouses.

Risk management covers both work place (occupational) safety as well as external safety (major accidents). Occupational safety is dealing with the whole range of incidents or accidents which can cause harm to personnel. This includes i.e. falling from a scaffold or ladder, tripping on a platform and also being exposed to chemical substances which are incidentally released from a containment.[1] Typically occupational safety deals with accidents with a relatively high frequency but with relatively low impact (not many people involved, recovering from injuries is possible). Whereas major accidents with external effects can affect more people and with lethal effects.

The contributing partners in SHAPE RISK WP2 are:

- Institut national de l'environnement industriel et des risques (INERIS), Verneuil en Halatte, France
- Bundesanstalt für Materialforschung und prüfung (BAM), Berlin, Germany,
- National Centre for Scientific Research (NCSR-Demokritos), Aghia Paraskevi (Greece)
- Health and Safety Executive (HSE), Buxton, United Kingdom (deputy leader)
- Rijksinstituut voor Volksgezondheid en Milieu (RIVM), Bilthoven, The Netherlands
- Netherlands Organisation for Applied Scientific Research (TNO), Apeldoorn, The Netherlands (WP2 leader).

[1] the inventory is <u>not</u> focussed on occupational health problems due to chronic exposures.

2. Method of working

Step 1:
The first step involved the invitation to the stakeholders in each country to give information with respect to the state-of-the-art on the identification, prevention, preparation, mitigation, repression and after care of workplace hazards and external hazards due to accidents. The stakeholders to be interviewed were the competent authorities (such as the Labour inspectorate, the Environmental Inspectorate), Seveso higher tier companies, Seveso lower tier companies and ATEX companies.

Step 2:
To facilitate the inventory a scheme was presented that consisted of a limited number of questions and a comprehensive explanation. These covered the methods used for the inventory of external safety hazards (major accidents) and the measures that can or should be taken to prevent/reduce risks; and with respect to workplace hazards (occupational accidents), aspects such as used methods, required information, characterization of workplace hazards and criteria to judge if the measures taken are effective. It was intended to try to achieve a form of standardization to be able to compare the situation in the various countries and to learn which positive performers contribute actively to safer industrial system. (The main deliverable of the SHAPE-RISK project). The aim was to see whether there is a form of continuity of risk management form work place accidents to major accidents.

Step 3
The proposal for the inventory of the state-of-the-art with respect to external safety and workplace hazard was complemented by a general questionnaire.

3. Presentation of inventory

The outcome of the inventories in France, Germany, Greece, the United Kingdom, Finland, Austria, Spain and The Netherlands on the management of occupational risks and external risks is presented in chapter 4: Comparison of management of occupational risks and chapter 5: Comparison of methods for determining external risks.

The state-of-the-art with respect to management of occupational and external risks must make clear:

- Are there different "players" in managing occupational and external risks? If so, do they communicate, do they interact and which problems/conflicts occur?
- To be able to understand how risk levels (either occupational or external risk levels) are determined, it is necessary to know if and how risks are modelled (risk inventory and evaluation, scenario's, effect modelling, damage modelling, end points, criteria).
- If the determination/calculation of risk levels of both occupational and external risks is clear, it should be possible to analyse if there are or could be any interactions.

4. Comparison of management of occupational risks

4.1 Determination of occupational risk

In Table 4-1 an overview of the risk assessment methods in the various countries is presented that are discussed in more detail in the paragraphs 4.1.1 till 4.1.5

Table 4-1: Method of assessment occupational safety

Country	Method
France	Risk matrix Probability vs. consequences
Germany	Use broad raft of legislations, hazard analysis, no definition of risk,
Greece	Semi quantitative risk assessment. There are no official requirements for quantitative risk assessment either for occupational or external (major) risks. Quantification of risk is sometimes proposed.
The Netherlands	Risk matrix Probability vs. consequences
United Kingdom	General risk assessments will be qualitative. For ATEX (DSEAR), most will be qualitative with occasional quantification. HSE leaflet “Five steps to risk assessment”.
Finland	Quantitative risk assessments are allowed, should a company choose this option. The general approach is, however, to use a semi-quantitative matrix approach (mostly 3 x 3 or 5 x 5 categories).The Competent Authority requests that the companies identify both "typical" and "worst case" scenarios.
Austria	Qualitative risk assessment for federal regulations + general risk matrix for site-specific assessment

4.1.1 France

The occupational and external risks are treated separately in France. The method of assessment is based on a table. An example.

Table 4-2: Risk assessment methodology for occupational risks in France

Product or activity		Risk assessment					
n°	***Identification***	***Hazard***	***Risk***	***Probability***	***Seriousness***	***Prevention safety measures***	***Safety improvements***
1	Vaporizing of paint	Ejection of VOC	Inhalation of VOC	4	3	extractor	Increase the capacity of the extractor
2	Vaporizing of paint		ATEX	4	4	Installation materials are suitable for use in hazardous place	Inerting

The probability that hazard will cause an accident can be placed in one of four classes by estimating how often it can be expected to occur :

Probability	
1	Improbable
2	
3	
4	Very probable

The seriousness is expressed to classify the consequences of a potential accident for life and health :

Seriousness		
1	Unimportant	injuries (accident but the worker can continue working)
2	Limited	serious injuries (accident and the worker has to stop working)
3	Serious	the worker has incapacity
4	Very Serious	death

Then the risk matrix consists in giving priority to the actions :

Table 4-3: Giving priority to actions on the basis of the risk matrix

Gravity					
4			PRIORITY 1		
3		PRIORITY 2			
2	PRIORITY 3				
1					
	1	2	3	4	**Probability**

4.1.2 Germany

The system of institutions for statutory accident insurance (berufsgenossenschaftlichen) and prevention, designed to prevent accidents in the workplace, occupational disease and risk to health from occupational factors, exists alongside the state system. The provisions of Chapter 2 of the Social Security Code *VII (Sozialgesetzbuch VII)* constitute the basis for the prevention mandate of the statutory accident insurers (Berufsgenossenschaften). These state that the statutory accident insurer shall not only give advice on but also carry out inspections to ensure occupational risks. Special mention is made of the need for collaboration between statutory accident insurers and the competent authorities at German Federal States responsible for occupational risks. They are both responsible for the implementation of the legal arrangements.

4.1.3 Greece

Occupational risk assessment is officially required by the Greek Legislation for every installation and workplaces (not only industrial) with two Presidential Degrees (P.D. 17/1996 and P.D.159/1999). An official methodology has not yet been established by the Greek authorities, although this is the intention in the near future. Three different organisations relevant to the subject have proposed their methodologies, which are being used in most of the industrial establishments in Greece.

<u>Technical Chamber of Greece</u>

The Technical Chamber of Greece has proposed the following methodology for big industrial installations which comprises 4 different phases.

4.1.3.1 Phase1 – Analysis of existing situation

- Meeting with the personnel and the management of the installation
- Collection and review of all relevant data (procedures, safety records, P&Is, fire protection, harmful parameters measurements, accident/incidents data, medical examinations, etc)

4.1.3.2 Phase 2 – Identification of hazards

- Interviews with the Safety Engineer and the Supervisors of the different sections
- Measurement of harmful parameters
- Ergonomic analysis of the installation
- Interviews with representatives of the personnel
- Questionnaires
- Hazards registration

4.1.3.3 Phase 3 - Risk assessment and hazards taxonomy

- Risk assessment of every potential hazard according to:
  - the criticality of consequences
  - the frequency of exposure to hazard
  - the probability of the event
- Taxonomy of hazards according to their potential risk
- Control of the effectiveness of the management system for occupational health and safety
- Additional measures

4.1.3.4 Phase 4 – Presentation of results

- Written Risk Assessment of occupational safety
- Risk Mapping of the installation
- Additional protection and safety measures (if necessary)

In order to perform phase 3, which demands a quantitative risk assessment, risk is calculated with the formula:

$$R = S*E*P$$

(R= Risk, S= Criticality, P= Probability, E= Exposure)

The following climax for the four parameters has been proposed:

RISK	=	CRITICALITY *	EXPOSURE *	PROBABILITY
1. Negligible		1. Negligible	1. Rare	1. Negligible
2. Low		2. Important	2. Limited	2. Very Low
3. Medium		3. Serious	3. Occasional	3. Low
4. High		4. Very serious	4. Frequent	4. Medium
5. Critical		5. Catastrophic	5. Permanent	5. High

Weighting factors

In order to perform the multiplication of the three factors to calculate risk, weighting factors are used for criticality, exposure and probability. In principle, a non-linear utility function is introduced for the various degrees of "Criticality" (for example severity in worker injury) while a linear scale is adopted for "Exposure" and "Probability". The linear scale in the "exposure" attribute is problematic since (for example) daily exposure (=permanent) to a hazard is not only five times more frequent than once a year exposure (=rare):

Criticality		*Exposure*		*Probability*	
Negligible	1	Rare	1	Negligible	1
Important	4	Limited	2	Very Low	2
Serious	8	Occasional	3	Low	3
Very serious	16	Frequent	4	Medium	4
Catastrophic	25	Permanent	5	High	5

According to the above (and after performing the multiplication of the weighting factors) the following numerical values are expected from risk calculation.

Risk is:

Characterisation	**Description**	**Protection measures**
1. R< 25	Negligible	Not necessary
2. 25 < R< 100	Low	Immediate actions not required. Inspection and control necessary.
3. 100 < R < 200	Medium	Immediate actions to reduce risk.
4. 200 < R < 400	High	Immediate actions to eliminate hazards and reduce risk.
5. R > 400	Critical	Immediate actions to eliminate hazards.

Risk Matrices

Yearly exposure (Exposure weight = 1)

Criticality / Probability	Negligible	Important	Serious	Very Serious	Catastrophic
High	5	20	40	80	125
Medium	4	16	32	64	100
Low	3	12	24	48	75
Very Low	2	8	16	32	50
Negligible	1	4	8	16	25

Negligible risk

Low risk

Medium risk

High risk

Critical risk

Monthly exposure (Exposure weight = 2)

Criticality / Probability	Negligible	Important	Serious	Very Serious	Catastrophic
High	10	40	80	160	250
Medium	8	32	64	128	200
Low	6	24	48	96	150
Very Low	4	16	32	64	100
Negligible	2	8	16	32	50

Weekly exposure (Exposure weight = 3)

Criticality / Probability	Negligible	Important	Serious	Very Serious	Catastrophic
High	15	60	120	240	375
Medium	12	48	96	192	300
Low	9	36	72	144	225
Very Low	6	24	48	96	150
Negligible	3	12	24	48	75

Daily exposure (Exposure weight = 4)

Criticality / Probability	Negligible	Important	Serious	Very Serious	Catastrophic
High	20	80	160	320	500
Medium	16	64	128	256	400
Low	12	48	96	192	300
Very Low	8	32	64	128	200
Negligible	4	16	32	64	100

Permanent Exposure (Exposure weight = 5)

Criticality / Probability	Negligible	Important	Serious	Very Serious	Catastrophic
High	25	100	200	400	625
Medium	20	80	160	320	500
Low	15	60	120	240	375
Very Low	10	40	80	160	250
Negligible	5	20	40	80	125

The above-mentioned methodology is only indicative and is not being performed officially or required by the Greek Legislation. However most of the big industrial establishments have adopted this methodology in their occupational risk assessments.

<u>Hellenic Institute For Occupational Health and Safety Methodology</u>

The Institute has presented a method for occupational risk assessment according to legislative requirements. For the determination and the qualitative evaluation of occupational risks the following tools are being proposed[1,2]:

- Safety check lists are being set up according to the type of risk (for example a general check list for all types of machinery, check lists for specific machinery such as forklifts, lift trucks, presses etc, check lists for electrical equipment, fire safety, falls, for risks associated with specific work activities etc).
- Questionnaires that help assess the risks, which are filled by the employees.
- Methods for the measurement of chemical and physical parameters in the work environment.
- Methods for the analysis and assessment of results and their comparison to the accepted Occupational Threshold Limit Values.
- Specific medical examinations in order to assess the effects of the work environment on employees' health.

<u>Ministry of Employment and Social Protection</u>

For small (less than 50 persons) installations the Ministry of Employment and Social Protection has distributed guidelines on how to perform an occupational risk assessment (www.osh.gr). These guidelines are derived from the HSE publications "5 steps to risk assessment" and define five simple steps to perform the assessment[3,4].

Step 1: Identify the potential hazards
Step 2: Define the potential "vulnerable" to risk personnel groups in the installation
Step 3: Evaluate the hazards and the protection measures
Step 4: Define the additional measures that should be taken
Step 5: Check, review and revise frequently the assessment
Checklists to assist Step 1 – 4 are included in the leaflet, which was distributed to small installations.

References

[1] Drivas S., Zorba K., Koukoulaki Th., "Methodological Guide for Occupational Risk Assessment and Prevention", ELINYAE ed., Athens 2001.

[2] Drivas S., Papadopoulos M., Occupational Risk Assessment, chapter 2 in "Guide for the health and safety of workers", ELINYAE – EKA ed., Athens 2004.

[3] Ministry of Employment and Social Protection Guidelines " Practical guidelines to conduct an occupational risk assessment in small installations - Five Simple steps ", Athens 1998

[4] Health and Safety Executives "Five steps to risk assessment"

4.1.4 United Kingdom

Legislation

Risk assessment is required in the Management of Health and Safety Regulations (MHSR) which applies to all workplaces. If the workplace is in the chemical process industries, then the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) applies. DSEAR implements ATEX 137 and the safety requirements of the Chemical Agents Directive.

No particular type or structure of risk assessment is prescribed. However, much guidance leans towards qualitative risk assessment for many occupational hazards (occupational exposure to toxic substances, manual handling, use of machinery, construction etc). An example is the HSE leaflet "Five steps to risk assessment" (http://www.hse.gov.uk/pubns/indg163.pdf) which uses the following structure:

1. Look for the hazards
2. Decide who might be harmed and how
3. Evaluate the risks and decide whether existing precautions are adequate or more has to be done
4. Record your findings
5. Review your assessment and revise it if necessary

As with major hazards, the UK approach is goal-setting and requires the level of risk assessment to be proportionate to the level of risk. Many industrial companies utilised quantified approaches (hazard analysis, including fault tree analysis) for significant risks, particularly when it is otherwise difficult to determine whether more precautions are needed.

DSEAR (which incorporates the requirements of ATEX) requires hazardous area classification. This is generally not risk based. However the Institute of Petroleum published a discussion document on risk-based area classification and further work in this area is being coordinated by the Energy Institute. DSEAR also requires a risk assessment for fire and explosion hazards. This can often be qualitative (http://www.hse.gov.uk/pubns/indg370.pdf).

4.1.5 Netherlands.

In the Netherlands the Ministry of Social Affairs is responsible for the legislation with respect to occupational risks. The Labour Inspectorate is the enforcement authority with respect to occupational risks. Since the implementation of the SEVESO II directive, the Safety report for SEVESO higher tier companies includes an overview of Loss of Containment scenario's per installation, whereby the effects for the workers is estimated. All possible direct causes (corrosion, erosion, low/high temperature etc.) need to be addressed in these scenarios. The Labour Inspectorate and the Environmental Inspectorate both judge the safety report.

Table 4-4: Risk assessment methodology example for occupational risks in The Netherlands

Location		Installa-tion	Loss of contain-ment type	Prob-ability	Effect	Risk as-sessment	Extent of the effect
Warehouse	Corridor A	Rack 1	Leakage drum, very flammable	Remote	Small	Acceptable / 3	Factory grounds
			Leakage drum, poisonous	Remote	Negligible	Acceptable / 2	Immediate surround-ings LOC
		Corridor A	Fire	Remote	Small	Acceptable / 3	Factory Grounds
	Corridor 1	Rack 1	Leakage Sack poisonous	Remote	Small	Acceptable / 3	Corridor 1
			Leakage fibre drum, poisonous	Very remote	Very large	High / 5	Corridor 1

Table 4-5: Risk assessment on the basis of the probability of occurrence and the effect within the establishment in the Netherlands

Effect / Probability	Negligible	Small	Considerable	Large	Very large
Very high	5	6	7	8	9
High	4	5	6	7	8
Average	3	4	5	6	7
Remote	2	3	4	5	6
Very remote	1	2	3	4	5

Explanation

Green = acceptable risk, no measures needed

Yellow = high risk, application ALARA-principle obliged

Red = unacceptable high risk, risk reducing measures are necessary

Table 4-6: Description of the effect qualification within the establishment in the Netherlands.

Effect	Omschrijving
1. Negligible	Small impact on workers
2. Small	Medical treatment of workers necessary
3. Considerable	Serious injury of workers
4. Large	Irreversible injury of workers
5. Very large	One of more fatalities

4.2 Actors/ Stakeholders and activities in the field of occupational risk.

The aim of the following Table is to give insight in the questions:

– What are the different “players” in managing occupational risks? Do they communicate, do they interact and what problems/conflicts occur ?

– Is there an activity or “player” in a particular country that gives such a positive drive to reduce the occupational risk level (or to avoid and mitigate occupational accidents) that it is worth following ?

– Are occupational accidents reported and registered? What is the follow-up with respect to diminishing the occupational risk level for a particular branch ?

Table 4-7: Activities related to occupational safety and “responsible” actors

Country	**Reporting of accidents obligatory?**	**Labour inspection focussed on occupational health and safety**	**Registration of accidents**	**Occupational Risk Prevention organisation**	**Improvement of working conditions**	**Preventive activities such as advises,training, measurements.**	**Mitigating consequences of accidents**
France	yes	Labour inspectors	CRAM	INRS OPPBTP	ANACT	CRAM, consultants	Responsability of company
Germany	yes	CA, HVBG	HVBG	HVBG	HVBG	BAuA, HVBG	HVBG
Greece	yes	Labour inspectors	Regional Headquarters of Labour inspectorate	KEPEK		ELINYAE KEPEK	
Netherlands	yes	Labour inspectors	Coordinated by the Ministry of Social Affairs	For SEVESO companies: responsibility of company: Safety Manager Arbo services	Responsibility of company: Safety Manager Arbo services	Arbo services, Society of Safety Managers, Branch certificates (VCA), certifying bodies, governmental initiatives like convenants, program reinforcement occupational safety.	BHV = Companies Relief Organisation/ For Seveso companies: own firebrigade
United Kingdom	Yes	HSE covers both occupational and Major accident inspection	HSE (RIDDOR)	HSE, RoSPA, CIA (responsible care)	HSE	HSE, Manufacturing Companies, Consultants	HSE (Land Use Planning), Local Authorities, emergency services
Austria	yes	yes	Central Labour Inspectorate	Central Labour Inspectorate + Allg. Unfallversicherung (general accident prevention agency)	Labour Inspectorate	Federal legal obligations	Not in the scope of occupational accidents

4.2.1 France

4.2.1.1 The external actors in France

– labour inspectors,
Responsible for enforcing all labour legislation and regulation including occupational health and safety. They have free access to all premises under their control and can impose all investigation they consider necessary. They may serve notices to employers or submit formal report to the public prosecutor. Under certain critical conditions, they also can impose to temporarily stop the process running.

– labour medical inspector,
They insure, in conjunction with labour inspector, that legislation relating to occupational hygiene and health protection at work is properly observed and supervise activities of occupational health services.

– INRS,
The National Research and Safety Institute (INRS - Institut National de Recherche et de Sécurité) for the Prevention of Occupational Accidents and Diseases works for employees and companies under the General Social Security Scheme, according to directives set by the CNAMTS. It provides technical assistance: studies and research, training in prevention, technical and documentary assistance, information (periodicals, posters, brochures, audiovisuals, web site).

– ANACT,
It is the national agency for improvement of working conditions. It is supervised by Ministry of Labour, and its task is to help companies to improve working conditions.

– CRAM,
Their budget is based on regional health insurance funds. They have to assist employers and employees in their preventive activities through advises, training and supervision. Consulting engineers (270) and controllers (460) can enter all premises covered by Social Security general scheme. They have received specific training. They can request all justified preventive action, and may use financial incentives. Also they may carry out any measurements and analyses using interregional CRAM chemistry and toxicology laboratories (8) or physical measurements centres (8).

4.2.1.2 The internal actors in France

- Management
The manager of a company is responsible for employees health and safety protection. This responsibility principle has been reinforced by "cassation court" into principle of efficiency responsibility.

- Employees representatives
Health safety and working committee (CHSCT) is compulsory for all locations with 50 employees or over. CHSCT is chaired by employer and made up of employee representatives.

- Employees

Occupational physician is providing strictly preventive service of evaluating employee's suitability on engagement and once a year at least, with special survey according to job nature or particular circumstances. They are spending third of their time to analyse and evaluate workplace activities. They are also providing advises and recommendations to employer.

4.2.2 Germany

4.2.2.1 The external actors in Germany

– BAuA (Federal Institute for Occupational Safety and Health)

The objectives of the BAuA and the focal points of its work are geared, in terms of the tasks it is assigned, to the basic concern for maintaining and improving safety and health at work. The models for this are the **safe design of technology** and the **human design of working conditions**. This also includes essentially the preservation and promotion of health and work capacity on the basis of a comprehensive health awareness and health behaviour.

– **C**ompetent **a**uthorities (CA) of the German Federal States *(Länder)*

They are responsible for enforcing all labour legislation and regulation in the field of occupational health and safety.

– HVBG

Insurance coverage:

The Berufsgenossenschaften or institutions for statutory accident insurance and prevention assume liability for the consequences of occupational risks, commuting risks (accidents) and occupational diseases. At present there are 35 Berufsgenossenschaften divided according to the branch of industry with which they are concerned. The law states that their prime responsibility is to prevent occupational accidents and diseases, to eliminate work-related health hazards, and, should an insured event occur, to compensate the injured person, the relatives or the surviving dependants.

Prevention:

Prevention policy is aimed at preventing occupational accidents, occupational diseases, and work-related health hazards. Prevention in a modern context is based upon an integral approach which encompasses measures in the field of occupational safety and medicine as well as health protection.

The industrial BGs are applying themselves to these tasks with success. The objective of prevention by the BGs is health and safety at the workplace. This includes advice and supervision, research, initial and further training, documentation (occupational risk) and public information.

4.2.2.2 The internal actors in Germany

– Management

The management of a company is responsible for employees health and safety protection. Methods that are used e.g. Responsible Care.

– **Occupational Safety Officer and company doctors**(come up to the requirements from Occupational Safety Act (ArbSchG) and Occupational Health Act (ASiG))

The employer must provide occupational safety officer and company doctors. These are supposed to support him and in occupational safety and health and in accident prevention. The tasks are:

- use of the rules in the field of occupational safety and health and accident prevention,
- assembly improved of occupational medicine and safety relevant knowledge and
- improve the effectiveness of all measures.

4.2.3 Greece

4.2.3.1 The external actors in Greece

– **Ministry of Employment and Social Protection**

All organization relevant to Occupational Health and Safety issues are administrated by the Greek Ministry of Employment and Social Protection.

– **Labour inspectorate**

The Labour Inspectorate is responsible for the implementation of the Greek Legislation on Occupational Health and Safety. Additional tasks of the Labour inspectors are:

1. Workplaces inspections and recommendations for safety measures
2. Consultancy and information to operators and managers
3. Physical, chemical and biological parameters measurements
4. Inspections, controls and recommendations to manufactures, commissioners and contractors.
5. Accident analyses and root cause analyses for accidents and occupational illnesses.

In cases of non-compliance with the legislation, the Labour Inspectorate must apply all the established by the Law penalties.

– **Centres of Occupational Risk Prevention (KEPEK)**

These centres are usually the regional Labour inspectorates, and they have the same obligations as the Labour Inspectorate. They also organize regional work-shops and training activities on occupational health and safety in their area.

– **Hellenic Institute for Occupational Health and Safety (ELINYAE)**

The aim of the Institute is to conduct various studies concerning the health and safety at work, to disseminate information through its relevant publications and to conduct training courses through its seminars.

– **The Greek Atomic Energy Commission**
This organisation is responsible for all matters concerning Ionizing Radiation: Licensing, monitoring, etc..

4.2.3.2 The internal actors in Greece

Management - The management of a company is responsible for employees health and safety protection. Additionally the management is responsible to conduct the Occupational Risk Assessment and to keep a hard copy of it in the installation for future controls.
The management must ensure the presence of a Safety Engineer and a Medical Doctor in the installation. The work hours of the Safety Engineer and Doctor depend on the number of employees in the installation.
Safety Engineer - His presence is required for every installation (not only industrial) but with different working hours depending on the number of employees. His duty is to ensure the safety of the work place. He is also responsible for keeping records of all accidents. He participates in the elaboration of the Occupational Risk Assessment
Labour doctor - His presence is required for every installation (not only industrial) but with different working hours depending on the number of employees. His duty is to ensure the health of the personnel and when needed to address further examination or medical assistance to the nearest hospital. He is also responsible for keeping the medical records of the personnel. He participates in the elaboration of the Occupational Risk Assessment
Employers representative - Operators working in installations with personnel above 20 persons have the right to elect a representative for Occupational Health and Safety matters. He participates in the elaboration of the Occupational Risk Assessment

4.2.4 United Kingdom

4.2.4.1 The external actors in the United Kingdom

The Health and Safety Executive (HSE) is the government regulator and inspectorate for all aspects of workplace health and safety. HSE also provides guidance on meeting the requirements of legislation, including on risk assessment.

Trade Federations including the Chemical Industries Association (CIA) produce some guidance and undertake initiatives to improve safety such as ‘Responsible Care’.

Insurers carry out their own inspections of insured companies and require may certain protective measures to be carried out, particularly in terms of fire protection.

4.2.4.2 The internal actors in the United Kingdom

The responsibility for safety is with company management. This will generally be devolved through line-management. There will usually be a professional safety advisor, with technical safety resource, to assist line management in carrying out risk assessment and in other aspects of managing for safety.

4.2.5 External and internal actors in The Netherlands

4.2.5.1 The external actors in the Netherlands

Labour inspectorate:

1. Uphold of laws in the field of occupational circumstances (a.o. Occupational Circumstances Law, Working Hours Law, Nuclear Energy Law, Machine Provisions)
2. Investigation as a result of complaints about occupational circumstances and reports of serious occupational accidents
3. Judgement of enterprises that come under the SEVESO guideline

ARBO Service (ARBO = abbreviation of labour circumstances)
Private service. Advises regarding a structured, systematic and adequate policy on occupational circumstances and absentee rate. Recognises and judges the hazards due to technical systems, the organisation and human behaviour. However their activities are not related to major accidents.

4.2.5.2 The internal actors in the Netherlands

The responsibility for safety is with company management. This will generally be devolved through line-management. There will usually be a professional safety advisor, with technical safety resource, to assist line management in carrying out risk assessment and in other aspects of managing for safety.

4.3 Occupational safety report

This is concerned with whether countries have different obligations with respect to occupational risks.

Table 4-8: Occupational safety reports

Country	All companies	Chemical installations (not SEVESO)	SEVESO higher tier	SEVESO lower tier
France	"Unique document"			
Germany	Hazard analysis			
Greece	Occupational Risk Assessment			
The Netherlands	Risk Inventory and Evaluation (RI&E)	Extended Risk Inventory and Evaluation (ARI&E) by means of scenario's. Some of these companies may also be lower tier Seveso site.	Safety report includes I hazards chapter on installation level whereby the effects on the workers are qualified	Identification of hazards and evaluation in accordance with Safety Management System.
United Kingdom	DSEAR assessment (ATEX), General Risk Assessments	DSEAR assessment (ATEX), General Risk Assessments	SEVESO II Safety Report (includes MAPP) DSEAR assessment (ATEX), General Risk Assessments	DSEAR assessment (ATEX), General Risk Assessments, MAPP (major accident prevention policy)
Austria	Does not exist as "safety report"			

4.3.1 France

Since 2001, in order to prevent accidents at company, French ministry in charge of work has obliged all companies to transcribe the actions done to increase safety, into a document ("the unique document"). It is kept by the Industry, and can be controlled by the labour inspector. The document has to be updated each year, or in case there is a change in the processed chemical products or in the organisation. To achieve this aim, French companies have to establish a safety management system that incorporates :

- hazard identification,
- risk assessment,
- setting priorities for action,
- implementation of prevention measures,
- monitoring,
- review.

This "unique document" is usually made by the person in charge of safety. This safety management should encourage employees to participate to the risk assessment. The risk assessment covers all types of risks :

- work equipment and plant (electrical hazards, falls, etc.),
- workplace (poor visibility, …),
- falls and falling objects,
- thermals burns,
- chemical burns,
- fires and explosion,
- etc.

4.3.2 Germany

Hazard analysis (Occupational Safety Act (ArbSchG))

For the assessment of the conditions of work a hazard analysis is to be carried out through the employer. It is derived from that which measures of the occupational safety are necessary. The assessment depends on the kind oft the activity.

A hazard can be the result of:

- the design and the arrangement of the workplaces and the place of work
- physical, chemical and biological influences
- the design, the choice and the use of the means of production, in particular working materials, machines, equipment and plants
- the design of the production and manufacturing processes, workflow and working time and their co-operation
- insufficient competence and guidance of employees.

4.3.3 Greece

Occupational risk assessment is officially required by the Greek Legislation for every installation and workplaces (not only industrial) with two Presidential Degrees (P.D. 17/1996 and P.D.159/1999). An official methodology has not yet been established by the Greek authorities, although this is the intention in the near future. Specific check lists for all domains of workplaces and guidelines to assist the assessment are provided by the Hellenic Institute for Occupational Health and Safety.

4.3.4 United Kingdom

The Management of Health and Safety at Work Regulations require risk assessments to be carried out and to be recorded. These risk assessments will generally be qualitative. There is no requirement for a safety report for occupational risk, although some occupational risks will be covered in the Seveso safety report for top tier sites.

4.3.5 The Netherlands

Since February 2004: Safety regulation for company's that are working with hazardous substances is modernised. Companies are obliged to draw up a so-called Extended Risk Inventory and Evaluation (ARIE) in which is being listed how the risk for severe accidents can be kept as low as possible. The former Occupational Safety Report (AVR) is lapsed. Aim: identifying priorities for actions, preferably preventive actions.

5. Comparison of methods for determining external (major accident) risks

5.1 Definitions

Tab.5-1: Definitions of risk

Country	Definition	Nature of risk assessment	Aim
France	A normative definition of risk. But what is used is the definition of major accident. “Major accident” shall mean an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances	Before 2003: “quantitative consequence” approach. Since 2003: a probabilistic approach based on the bow-tie and analysis performance of safety barriers is being introduced.	Demonstrate that hazards are identified and risks controlled. Prepare land use planning and emergency plans.
Germany	No officially approved definition of risk	Deterministic approach: based on the possible consequences. Possible future use of probabilistic risk assessment.	Licensing procedure from SEVESO II plants, Land use planning
Greece	No officially approved definition of risk	Semi-quantitative approach	Licensing, land use planning, emergency response plans.
The Netherlands	Locational Risk (PR) Societal Risk (GR)	Fully quantitative probabilistic approach: likelihood of fatal injuries among the public	Mainly land use instrument
United Kingdom	Individual risk Societal risk	Risk assessment proportionate to the level of risk: COMAH depending on the level of societal risk: from qualitative through semi-quantitative to QRA.	Land use. Prioritisation of risks for action
Finland		Quantitative risk assessments are allowed, should a company choose this option. The general approach is, however, to use a semi-quantitative matrix approach (mostly 3 x 3 or 5 x 5 categories). In its guidelines, the Competent Authority requests that the companies identify both "typical" and "worst case" scenarios. The semi-quantitative matrix approach is normally used for assessing both of these types of scenarios.	
Austria	? Definition = Seveso II	Seveso II objectives	
Spain	*Zona de intervención* (ZI) It is the area where immediate protection is justified due to the damage level caused by the effects of a certain accident. *Zona de alerta* (ZA) It is the area where immediate protection is not justified (except for critical groups of the population) due to the damage level caused by the effects of a certain accident. Population within this area may however perceive the effects of the	In Spain, risk assessment is fundamentally based on a deterministic approach	

	accident.*Zona dominó* (ZD) It is the area where severe damage to property (process and storage equipment) is expected due to the effects of a certain accident		

5.2 Actors and activities in the field of external risk

The aim of the table is to give insight in the question:

- What are the different "players" in managing external risks? Do they communicate, do they interact and what problems/conflicts occur?
- Is there an activity or "player" in a particular country that gives such a positive drive to reduce the external risk level (or to avoid and mitigate accidents) that it is worth following?

Tab. 5-2: Activities related to external safety and "responsible" actors

Country	**Reporting of accidents obligatory?**	**Licensing**	**Safety Analyses**	**Inspections**	**Land Use Planning**	**Emergency Response plans**
France	Yes and controlled by the environment inspector					
Germany	Yes Seveso II plants, ZEMA Database	Länder: building regulations, Pollution Control Act, Federal Water Act, Disaster Prevention Act, Chemical Act,	Länder	Länder: Pollution Control Act, Disaster Prevention Act	Länder	Länder
Greece	yes	Ministry of Development (Higher tier Seveso installations Prefectures Industrial Division (Lower tier Seveso Iinstallations)	Ministry Of Development (Higher tier Seveso Installations) Prefectures Industrial Division (Lower tier Seveso Installations)	Ministry Of Development – Prefectures Industrial Division - All relevant ministries (Public Health, Environment, Employment and Social Protection)	Ministry for the Environment, Physical Planning and Public works	Civil Protection Organization – Prefectures
The Netherlands	For Seveso plants coordinated by the Ministry of Social Affairs	Competent authority might be: municipality, province special environmental Agency (DCMR)	Industrial enterprises and consultants	Environmental Inspection, Labour Inspection, Competent authority – fire brigade	Municipalities, provinces	Industrial enterprises, local authority, Fire brigade, emergency services
United Kingdom	yes	HSE, Environment Agency, SEPA	Duty holder, consultants, HSE for land use planning, Environment Agency (EA)/ Scottish Environmental Pro-	HSE, Environment Agency, SEPA	HSE, Local Authority	Local Authority, Emergency services, Environment agency/SEPA, Duty holders, HSE (onsite only)

			tection Agency (SEPA)			
Finland			Finnish Safety Technology Authority (TUKES)	Finnish Safety Technology Authority (TUKES)		
Austria	Yes (district auth.)	Check: district + regional auth. (Laws: federal)	district + regional auth. (Laws: federal)	Community + regional auth. (Laws : regional)	Community + regional auth. (Laws : regional)	
Spain			Ministry of Interior			

5.3 Methodology for risk analysis

A full-scale risk analysis includes the following topics :

- **hazard identification:** *to find the parts of the installation, which are of importance with respect to safety including mapping of the origin and causes of possible accidents and the quantities and properties of chemicals used.*
- **analysis of accident scenarios:** *to describe the possible modes how an accident can develop, e.g.: a malfunction in a valve triggers other failure modes and gives a release of a dangerous compound to the environment threatening humans.*
- **analysis of frequencies and consequences:** *the accident scenarios are analysed more thoroughly. The probability of a scenario occurring and the consequences resulting from the scenario are calculated. The consequences are often measured as the impact on human health or mortality. Also, the environmental impacts might be used as a measure.*
- **evaluation of the total risk:** *the final evaluation of the risk includes a ranking of the scenarios found and might be expressed as a sum of the risk of all the scenarios. The probabilistic approach will define the risk as the product of the frequencies and the consequences. The deterministic approach is based on the possible consequences only.*

The possible levels of risk assessment are:

- **Qualitative** (Q), in which frequency and severity are determined purely qualitatively;
- **Semi-quantitative** (SQ), in which frequency and severity are approximately quantified within ranges; and
- **Quantified risk assessment** (QRA), in which full quantification occurs.

Tab. 5-3: Methodology for risk analysis

Country	Methodology
France	In France, since 1810, companies have to provide a safety report. It has to be reviewed in case of modification. So each company has to comply with French regulations, and to provide a safety report to demonstrate how risk can be avoided.
Germany	Do not calculate frequencies
Greece	The Greek Legislation does not require a quantitative Risk Assessment officially. However, it is commonly suggested (according to the guidelines provided by NCSR Demokritos) that safety reports should include a risk assessment with the following parts: Hazard Identification Accidents frequency calculation Definition of potential consequences of accidents Risk estimation The method to conduct a QRA is fully described in a manual edited by the Systems Reliability and Industrial Safety Laboratory of NCSR Demokritos in collaboration with the University of Crete and the National Technical University of Athens and it is distributed to the stakeholders.
The Netherlands	The method of conducting a QRA in the Netherlands is fully described in CPR-18E: "Guidelines for Quantitative Risk Assessment", also called the Purple Book. It includes, among other things, the LoC events and their related frequencies, and how PR and GR shall be calculated and presented. Behind this Purple Book, there are three other CPR guidelines: CPR-12 (Red Book) on processing probabilities, CPR-14 (Yellow Book) comprising models of assessing the effects of a release of gas or liquid and CPR-16 (Green Book) with models to assess the damage to health, life and property.
United Kingdom	In UK the level of risk assessment is determined by means of proportionality. The existing HSE published guidance states `the depth of the analysis in the operator's risk assessment should be proportionate to (a) the scale and nature of the major accident hazards (MAHs) presented by the establishment and the installations and activities on it, and (b) the risks posed to neighbouring populations and the environment i.e. the assessment has to be site specific.' The risks referred to here include both individual and societal risk. A range of risk assessment, from qualitative through semi-quantitative to QRA, may be performed, depending on the level of societal risk estimated by a screening process. The precise level and structure of the risk assessment to be used by industry is not prescribed, as UK health and safety legislation is goal-setting rather than prescriptive.
Finland	Quantitative risk assessments are allowed, should a company choose this option. The general approach is, however, to use a semi-quantitative matrix approach (mostly 3 x 3 or 5 x 5 categories). In its guidelines, the Competent Authority requests that the companies identify both "typical" and "worst case" scenarios. The semi-quantitative matrix approach is normally used for assessing both of these types of scenarios.
Austria	Deterministic, no calculation of frequencies
Spain	·Hazard identification, only credible scenarios based on expertise (frequency assessment can be use to discard scenarios) ·Only effect assessment, CPR-14, AIChE, etc. (no mandatory methodology)· Presentation of ZI, ZA and ZD distances ·Ranking of accidents (3 categories)

5.3.1 Hazard identification

Hazard identification refers to the identification of major accident scenarios.
For each country it is indicated how the accident scenarios are identified and if there is a guideline that standardizes this first step in risk analysis and if so what is it.

Tab. 5-4: Hazard identification

Country	Methods	Specified Major Accident Hazard scenarios to be considered
France	Since 2003, French ministry in charge of Environment and INERIS has been working on the evolution of the French approach. The new approach is based on the identification of bow-tie (fault tree and event tree) for many accident scenarios and the analysis of the performance of the safety barriers put in place for each event. The hazards identification is based on : - risk analysis methods like : Preliminary Hazard Analysis, HAZOP, etc. - expert judgement and - lessons learnt from the accidents described in the ARIA data base (and the Industry data base if it exists). These scenarios considered for quantification are proposed by the operator, and checked by the environment inspector (competent authority).	Before 2003, the scenarios to be considered as minimum in a risk analysis were listed in the document: "Control of Urban Development around High-Risk Industrial Sites" (1990). This document consists of a list of scenarios and reference criteria based on possible effects of the accident. Reference scenario's were : BLEVE, VCE and UVCE, instantaneous and complete loss of containment, full bore rupture of the pipe which generates the biggest mass flow rate, fire of the biggest pool, explosion of the gaseous phase for atmospheric tanks, Boil-over of flammable liquid storage.
Germany	Methods are: FMEA, HAZOP techniques; What if, expert judgement and casuistry of accidents form the ZEMA data base.	
Greece	Essential steps to identify all potential hazards in an installation (according to the methodology proposed by the NCSR Demokritos) are the following: Good Knowledge of the processes and collection of all necessary data (P&Is, MSDS, Meteorological information, etc) Identification of potential critical areas in the installation Identification of potential critical processes and operations Definition of initiating events that can lead to a potential accident Identification of prevention, protection and mitigation measures Identification of protection, control and support systems Definition of systems requirements Grouping and final selection of initiating events Hazard identification methods, systematic and analytical, either inductive like HAZOP, or deductive like the MASTER LOGIC DIAGRAMs, are used in order to define the list of initiating events.	Accident sequences involving: Initiating events Hardware failures of protective hardware Human failures and leading to: Direct release of Toxic substances (lighter & heavier than air) BLEVE (Flammable substances) UVCE (Flammable substances) Flash fire (Flammable substances) Jet fire (Flammable substances) Pool fire (Flammable substances) Detonation (Explosive materials) Deflagration (Explosive materials) Fires resulting to toxic clouds (Agrochemicals)

The Netherlands	Guidelines for Quantitative Risk Assessment (so called "purple book": CPR-18E)	Loss of Containment events to be chosen are described in the CPR-18E which provides recommended LoC events for various types of installation and equipment (tanks, process vessels, heat exchangers, pumps, transport units, piping, loading/unloading facilities, etc.). LoCs comprise catastrophic ruptures and (more likely) smaller leaks.
United Kingdom	Industry standard or bespoke checklists for hazard identification, Safety reviews and studies of the causes of past major accidents and incidents, FMEA (Failure Mode and Effect Analysis); LOPA (layer of protection analysis), HAZOP (Hazard and Operability Studies), Job safety analysis (e.g. Task Analysis), Human error identification methods, Former ICI 6 stage hazard study is used a lot in the UK, Exothermic reaction chemical assessment procedures	HSG190 (HSE guidance on writing Safety Reports) Range of events leading to LoC. Events modeled include catastrophic failure, full bore rupture of piping, small holes, natural disasters e.g. seismic, aircraft impact, operator/control system failure
Finland	All systematic hazard identification methods, or combinations of these, are accepted by the authorities as long as their coverage and depth are sufficient for the study at hand. Most hazard identification and risk analysis methods used in Finland are based on a team approach, i.e. on expert judgement. According to the guidance given by the Competent Authority in Finland, companies are obliged to be aware of past accidents that have happened within the own enterprise or in other companies active in the same sector, and of past accidents that have involved the chemical studied regardless of where these accidents have happened.	
Austria	Deterministic	Depends on substance quantities
Spain	Scenarios defined by owner by means of using: Expert judgement primarily (support from CPR-18) Operability analyses (HAZOP, FMEA, What if...?) Accident Casuistry Scenarios may be discarded if proven to be non-credible or unrealistic	

5.3.2 Frequency calculation

Tab. 5-5 Models used for frequency calculation

Country	Models	Data sources
France	the probability of a scenario is evaluated with the experts and the knowledge of the Industry. In the new approach, the performance of the safety barriers is assessed in terms of "level of confidence" and in SIL (according to the IEC 61508 standard). This performance has an influence on the probability of the final event of a scenario.	
Germany	Not normally performed. However, a quality assured compilation of reliability data and several pilot studies exist. The initiating event frequencies and unavailability's of operational and safety systems may be stated **qualitatively** (e.g. yes/no decisions 1/0).). If the risk is tolerable, i.e. a serious hazard may reasonably be denied, the design of the plant is acceptable (i.e. the state of the art of safety technology is complied with).	

Greece	The use of any model for the calculation of incidents frequencies is open to the interested parties. However all the results are being reviewed once the safety report is brought to the Greek authorities by specific research organizations (like the NCSR DEMOKRITOS) acting as consultants and evaluators.	When quantification is performed generic frequencies for initiating events, hardware failure rates and human error rates are used. Whenever used, reliability models are combinations of event trees and fault trees.
The Netherlands	Models: CPR-18 + location specific data: climatology, ignition sources, presence of public, vulnerability models, etc.	Data sources: Climatic data, demographic data, OREDA, E&P Forum, AMINAL, company / branch specific figures
United Kingdom	Historic data, Event tree, Fault tree, TNO Purple book, Lees “Loss Prevention in the Process Industries” Frequency data is sometimes also derived by fault tree analysis. For Q or SQ risk assessment, expert judgement may often be used, benchmarked against generic values. Data for use in event trees come from a range of sources. Probabilities of weather type, wind direction are usually from the nearest weather station that keeps such data. Ignition probabilities may be generic (e.g. Cox, Lees and Ang) but some ignition probability models are starting to be developed (e.g. Atkins CRR).	Most frequency figures in QRA utilise generic values based on historic data. Databases held by the larger industrial companies and by specialist consultancies; the Purple book; Lees; CCPS guidance; offshore oil industry data including OREDA (reliability data) and the hydrocarbon release data (HSE); FRED (HSE data). Although some methods are available to modify generic data according to the quality of safety management (e.g. PRIMA, I-RISK, MANAGER), this is unusual and would require careful justification that management standards would be maintained. HSE have recently undertaken a review of such methods.
Finland	Frequency calculations are normally not carried out. Should a company choose to do so, it also has the right to select the model. Most likely a model used by foreign companies within the same (international) enterprise is then used also at the Finnish subsidiary.	
Austria	no	
Spain	Only for elaboration of fault trees to proof scenarios unrealistic for the IS	

5.3.3 Consequence assessment

Tab. 5-6: Models used for consequences assessment

Country	Models	Data sources
France	Assessment of the effects caused by the different accident scenarios, e.g. dispersion of toxic substances, pressure waves (Δp), heat radiation (E_r) are modelled.	
Germany	Assessment of the effects caused by the different accident scenarios, e.g. dispersion of toxic substances, pressure waves (Δp), heat radiation (E_r) The decision which assessment criteria and limits are to be used, is depending from the agreement between the authorities and the operators.	
Greece	The use of models for the calculation of consequences effects is open to the interested parties. It is required however that consequence assessment includes the consequences from the accident scenarios, as presented previously, and the dose zones. Again the results are being reviewed by specific research organizations.	SOCRATES (Demokritos) PHAST (DNV) Degadis SLAB

The Netherlands	In QRA's calculations of physical effects of releases are commonly carried out with models recommended in CPR-14, the Yellow Book. Damage and consequence modelling is based on recommendations in CPR-16, the Green Book. In consequence calculations, no protection measures into account	EFFECTS PHAST
United Kingdom	Consequences which would usually be modelled for major hazards include release rates, pool evaporation, jet entrainment, gas dispersion, BLEVE fireball, pool fire, jet fire, vapour cloud explosion. Harm criteria are required for use with all these models. TNO Yellow book and green book IChemE books on explosion modeling, damage effects, thermal radiation, chlorine toxicity Lees "Loss Prevention in the process industries" TNO multi-energy method A number of commercial and in-house company software packages are in common use. HSE is currently undertaking a review of available software to inform assessors of top tier COMAH/Seveso safety reports.	PHAST (DNV) FRED (Shell Global Solutions) HSE have a range of in-house software for various applications ACDS (environmental gas dispersion) is often used for passive/buoyant gas dispersion SEVEX occasionally used
Finland	Atmospheric dispersion calculations are frequently carried out. Internationally known models, as well as VTT's RISKWIT software, are used for that purpose. 2-4 atmospheric situations are normally addressed for each release scenario. Sometimes consequences to humans and to property due to pressure or heat are also calculated. In special cases the influence of a chemical release on the wastewater treatment plant, on the groundwater, and on watercourses are also calculated.	
Austria	Reference scenarios for Land Use Planning	
Spain	Requires assessment of the consequences for every scenario. This can be done by using any model as long as it is internationally recognised	A simple and conservative approach is preferred. In general, the Yellow Book models (implemented in the software package *Effects*) are used nation-wide in Spain. Properties: MSDS, DIPPR, SERIDA Toxicity: EPA (http://www.epa.gov/oppt/aegl/chemlist.htm)

5.3.4 Harm Criteria/ End points for consequence calculations

Directly or indirectly the majority of the surveyed countries use *dose* as end points of consequence calculations.

Effects of toxic substances:
LC50 (Lethal Concentration 50): The concentration in the air of a toxic substance, which may cause fatalities to the 50% of the population via inhalation of the substance for a duration of 30 minutes. [Equivalent dose $D_{50}=(LC50)^n*30min$ where n depends on the substance].
LC1 (Lethal Concentration 1): The concentration in the air of a toxic substance, which may cause fatalities to the 1% of the population via inhalation of the substance for a duration of 30 minutes. [Equivalent dose $D_{01}=(LC1)^n*30min$ where n depends on the substance].
IDLH (Immediately Dangerous to Life and Health): The maximum concentration in the air of a toxic substance in which can be exposed a person for 30 min without any irreversible for his/her health damages or injuries which can prevent him/her from leaving the area.

Effects of Thermal Radiation

For the calculation of the dose in TDU (thermal dose unit: 1TDU = 1 $(KW/m^2)^{4/3}$*s) the following formula is used:

$D = Q^{4/3} * t$ Q: the radiation intensity in W/m^2 t: time in seconds

Effects of Overpressure

Given that the dose has a weak dependence on the duration of the shock wave, here peak overpressure is used instead of dose.

Tab. 5-7: Criteria

Country	Criteria

France	<u>Thermal radiation</u> :
	• For the effects on structures :
	  • 5 kW/m^2, significant breaking of glass windows;
	  • 8 kW/m^2 : domino effects;
	
	• For Human beings :
	  • 3 kW/m^2 ou 600 $[(kW/m^2)^{4/3}]$. s, irreversible effects ;
	  • 5 kW/m^2 ou 1000 $[(kW/m^2)^{4/3}]$. s, lethal effects (heavy hazards) ;
	  • 8 kW/m² or 1800 * $[(kW/m^2)^{4/3}]$. s, lethal effects (very heavy hazards).
	
	<u>For toxic</u>, SEI (depending on the substance for irreversible effects), SEL (1% and 5%) for lethal effects
	
	<u>For explosion</u> :
	• For the effects on structures :
	  • 20 mbar : significant breaking of glass windows,
	  • 50 mbar : light damages to structures,
	  • 140 mbar : significant damages to structures,
	  • 200 mbar : domino effects,
	  • 300 mbar : very heavy damages to structures
	• For Human beings :
	  • 20 mbar : irreversible effects,
	  • 140 mbar : lethal effects

Germany	The different accident scenarios are valuated by using assessment criteria, e.g. AEGL, EPRG values for toxic substances, limits for peak on-side pressures and heat radiation intensity.
Greece	3 zones depending on the dose levels are defined in the neighbourhood of the establishments as following: Zone I: Protection of Emergency Response Forces Zone II: Population Protection – Serious consequences Zone III: Population Protection – Medium consequences Protective Actions Zones (Dose zones) as defined by the Greek Ministry of Environment **Toxic (dose)** **Thermal Radiation (TDU)** **Overpressure (mbar)** **Zone I** $D_I=(LC50)^n * T$ 1500 350 **Zone II** $D_{II}=(LC1)^n * T$ 450

	140 **Zone III** D_{III}=(IDLH)^n * T 170 50 • **where: T=30 min** • **and n: depends in the substance** Zone I should not extend beyond the " fence:" of the installation.
The Netherlands	End point of consequence calculations is the distance where 1% lethality would occur under the most adverse (climatological) conditions. Typical values are: • For heat radiation: ~12.5 kW/m^2 for 20 sec. exposure duration (~600TDU) • For explosion: 100mbar peak overpressure • For toxic effects: D_{01}
United Kingdom	To screen for offsite risk, a criterion of 50% fatality is often used. For Toxic, this is a lethal dose, concentration versus time, D_{50} For Flammables, this is thermal dose unit (TDU) which is 1800 TDU For land-use planning 'HSE dangerous dose', equivalent to 1-5% fatality is used.
Austria	Endpoints for thermal radiation, overpressure, toxic (IDLH)
Spain	**Heat Radiation**.: Heat load is used for ZI & ZA (D = $q^{4/3}$·t) ZI = 250 TDU ZA = 115 TDU ZD = 8 kW/m^2 Overpressure: ZI = 125 mbar ZA = 50 mbar ZD = 160 mbar Toxic: Complex (new) approach based on the (arranged by preference): AEGL (EPA, 1999), ERPG (AIHA, 1998) and TEEL (Craig y Ray Lux, 1998) values ZI = AEGL-2 or ERPG-2 or TEEL-2 ZA = AEGL-1 or ERPG-1 or TEEL-1 Missile: ZI = Max range of missiles with impulse > 10 mbar·s (95 %) ZA = Max range of missiles with impulse > 10 mbar·s (99,9 %)

5.3.5 Risk calculation

Tab. 5-8: Risk calculation methods

Country	Method	Presentation
France	A"semi-quantitative approach" based on the bow-tie.	Risk mapping Zones of SEL (appearance of lethality : SEL 5 % and SEL 1%), SEI (appearance of irreversible effects), pressure waves and heat radiations are plotted on topographical maps. These maps are use for land-use planning decisions and for the preparation of emergency plan
Germany	In order to assess the risk the quantitatively determined and valuated consequences are combined with the qualitative assessment of their likelihood (1 = enter; 0 = don't enter).	
Greece	A quantitative risk assessment is not required by the Greek legislation. However it is suggested (and unofficially required by the Greek authorities) that the safety reports of the installation comprise an assessment of accident scenarios. Risk calculation is not required by the Greek legislation. Only the extension of the three Dose Zones is an informal requirement by the ministry of Environment. However in various evaluations and reassessments by reviewers of the submitted safety studies, individual risk contours for each accident sequence, as well as overall individual risk is supplied.	Results are presented in terms of the list of possible accident scenarios and the extension of the three zones (for each scenario).
The Netherlands	The risk figure for locational risk (PR) comprises the following elements, with corresponding frequencies and/or probabilities: Initial accident frequency (LoC-event) Probability of development: system reactions, influencing the magnitude of the effects (e.g. duration of release, spreading of pool) Probability of the effect: ignition direct, delayed or not Probability of exposure: weather conditions like stability class, wind velocity, wind direction Probability of damage / injury / death: response through probit function The PR at a certain location is calculated by multiplication of all these probability figures and summarise the results over all LoC events and developments.	Locational risk (PR) is expressed in frequency [yr^{-1}] and is presented in iso-risk contours over a topographical map of the surroundings of the establishment. Typically, contours are presented for PR = 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 10^{-8} /year. Societal risk (GR) is expressed in the square of the number of fatalities per year [$N^2.yr^{-1}$], and is presented is a (double logarithmical) curve with the number of victims against the frequency of occurrence.
United Kingdom	Risk assessment techniques range from a simple qualitative approach to a detailed quantitative assessment. SAFETI (DNV) Shepherd (Shell) Spreadsheets RISKAT (HSE use for land-use planning) RISK-PLOT (ERM)	Risk Matrices, FN plots, Bow-tie diagrams or other ways of presenting lines of defence

Finland	Quantitative risk calculations are seldom carried out. The risk is normally given as a risk category given by the risk matrix used. Fault Tree and Event Tree Analysis are most commonly used in those rare cases where the risk is quantified.	No common approach is known to exist, but it is believed that the Dutch approach (see the Dutch input) is the first choice, should companies choose to present their total risk graphically.
Austria	no	
Spain	Quantification not necessary at the moment (only required in special cases)	Plots with ZI, ZA and ZD

5.3.6 Uncertainties

Tab. 5-9: Uncertainties

Country	Uncertainties
The Netherlands	Uncertainties: Factor 10 – 100. Quote from CPR-18: recent figures often higher.
United Kingdom	Duty holders are required to consider uncertainty. This is often done qualitatively and/or by making conservative assumptions.
Spain	Consequences: Generally < factor of 2 per model. May accumulate. Most uncertainties due to modelling choices by the analyst, when no strict protocol exists or model validation lacks.

5.3.7 Acceptability criteria

Tab. 5-10: Risk acceptability criteria

Country	Risk Acceptability criteria	Safety Report Acceptability criteria
France	no explicit risk acceptability criteria. A new legislation was adopted in 2003 and now, according to the law, the consequences of reference accidents should be kept on site. But for installation under the scope of the SEVESO directive, Land Use Planning is organised to limit the number of victims in case of an accident with off site effects. 'Droit de préemption': right to acquire the area (by local government) 'Droit de délaissement': right to remain for the time being, but abandonment in due time 'Droit de expropriation': right of expropriation 'Droit de prévention': right to modify to installation These legal instruments enable to regain the zones in the surrounding of a plant where the risk is very high.	

Germany	It has to be decided whether the risk determined may be tolerated. The relevant criterion is whether a serious hazard may occur or not. If the risk is tolerable, i.e. a serious hazard may reasonably be denied, the design for safety of the plant is acceptable (i.e. the state-of-the-art of safety technology is complied with). If the risk is not tolerable, risk-reducing measures must be fixed. No risk acceptability criteria are defined	
Greece	There are no risk acceptability criteria in Greece	
The Netherlands	Locational risk (PR): No vulnerable objects are allowed within PR = 10^{-6}/year contour. This is a strict norm value, informally applied since approx. 1990 and will have regulatory status from mid 2004. Societal risk (GR): Frequency of 10 deaths GR < 10^{-5}/year, frequency of 100 deaths GR < 10^{-7}/year, etc. This is an indicative value, a decision criterion for spatial planning. Deviation shall be motivated by competent authority, on the basis of socio-economic arguments. The citeria are informally applied since approx. 1990 and will have regulatory status from mid 2004	
United Kingdom	Upper level IR worker = 10^{-3}, IR public = 10^{-4} Lower level IR work = 10^{-6} Societal Risk FN point of N=50 at 1 in 5000 likelihood given in R2P2 and a slope of –1 on the FN curve	Detailed criteria given in Safety Report Assessment Manual: http://www.hse.gov.uk/hid/land/comah2/index.htm
Spain	No formal (national) acceptance criteria for external risk are set (yet) in Spain. However, in Cataluña risk acceptance criteria (copied from the Netherlands) have been drafted and will be given to the regional Parliament for official recognition early in 2005.	

6. Hazard Prevention and reduction

Tab. 6-1: Hazard prevention and reduction measures

Country	**Identification of further risk reduction measures**	**How does it feed into Safety Management System**
France	For a given scenario (given fault => critical event => dangerous phenomena) requirements for safety barriers in order to have an acceptable level of risk The tools used are the risk graph to have a first idea of the level of risk; useful in a work group The requirements for safety barriers will depend on : gravity of the consequences and level of exposition of the targets (time of exposition and possibility to escape after an accident), and the probability of the given fault. Risk is reduced by implement of safety barriers : - to avoid (elimination of scenarios) - to prevent (reduction of probability of event), - to Detect / Control, - to Mitigate (reduction of gravity). Performance of safety barriers will be defined by three parameters : - their level of confidence, linked to the probability of failure on demand - their efficiency, - their response time.	SMS must be described in the SEVESO II Safety Report
Greece	There is no systematic and official (or unofficial) approach to risk reduction through prevention (i.e. accident frequency reduction). Introduction of additional safety measures through the risk analysis procedure is not exercised since there are not “acceptable” risk levels that could form a legal basis for requiring such measures. When this is done it is on a case by case basis and according to existing deterministic criteria. To mitigate the effects of an accident Seveso installations have to develop the Internal and the External Emergency Plans. The Internal Emergency Plan is organized by the installation and must be completed and included in the safety report of the establishment. This Internal plan should be reviewed every three years and should include all changes and modifications of the installation. Additionally drilling exercises should be performed in collaboration with the Local Fire Brigade. The External Emergency Plan or Plan for Major Technological Accidents is being organized in collaboration with the public authorities. It refers to major accidents mainly dealing with hazardous substances and/or release of energy (overpressure, thermal radiation). The General External Emergency Plan is a part of the General National Plan of Citizens Protection. The External Emergency Plan includes all the necessary measures to be taken outside the installation to reduce accident consequences according to the safety reports and taking into account the domino effects in the neighbourhood installations.	SMS must be described in the SEVESO Safety Report.

United Kingdom	A hierarchy of safeguards is required to be considered i.e. Inherent safety, prevention, control and mitigation As a minimum, good practice standards should be employed. These would include HSE guidance on legislation, British/European/International/American standards, industry guidance. If the level of risk is low enough, then this is sufficient If the risk is higher (but still tolerable), then the risk must also be demonstrated to be ALARP	SMS must include risk assessment to prioritise risk reduction. SMS must be described in the SEVESO II Safety Report (COMAH). Guidance on suitable SMS given in HS(G) 65 (published by HSE)
Netherlands	A hierarchy of safeguards is advised in the following order: pro-active (tackling the source) – prevention – preparation – repression. For SEVESO companies it should be made plausible that the Safety Management System is functioning by describing the organisation, the identification of hazards and judgement of risks, supervision on the execution of the SMS, control in case of modifications, planning in case of emergencies, supervision on the performances, audits and evaluation.	
Finland	The Finnish legislation suggests that companies should first look for measures to eliminate the hazard. If this is not feasible, technical measures to reduce the risk for the affected work force as a whole should be preferred before those protecting individuals. The last way to reduce the risk is by organisational actions, such as training, work permits and instructions, etc.	
Austria	Part of permit system	

7. Synergies and Conflicts

This chapter deals with the synergies and conflicts between occupational safety and external safety.

Tab. 7-1: Synergies and conflicts for occupational and external safety

Country	Synergies	Conflicts
France	occupational ATEX risk analysis can be helpful for many items of the risk assessment done for external safety (SEVESO) (understanding of the process of the considered facility, Safety Important Items, identification of possible malfunctions), the "unique document" can be considered as a management tool, in France the risk assessment procedure is similar for industrial risk and for ATEX risk	The scenarios to be considered are not identical : for SEVESO, the scenarios of major accidents have to be considered, but for ATEX, every scenario where a worker might be injured has to be considered and, generally, it does not correspond to a major accident scenario, In order to comply with SEVESO regulation, for a building inside which a gas or vapour explosion has to be considered, a determinist point of view would impose to protect the building by venting ; however, in case of an explosion inside the building, the workers would be injured of killed. A preventive measure (e.g. a well maintained and secured ventilation) should be preferred because it would be efficient as for workers safety as for building integrity.
Germany	The connection between SEVESO II and ATEX is the definition of a major accident as a major emission, fire, or explosion. Measures to the explosion protection are also measures to avoid major accidents. Therefore the hazard analysis is **a part** of the safety assessment of a SEVESO installation with regard to the explosion protection in Germany. In addition also all other fields of occupational safety (hazard analysis) must be judged.	Different institutions are responsible for inspection (SEVESO II, Occupational safety), larger administrative overhead, higher costs, longer permission times
Greece		Separating external risk from occupational safety in the absence of unified and consistent criteria could result in conflicting situations. For example, only people "outside the fence" of an installation are considered as subjects to the risk. In this way some important and severe accidents with no substantial consequences "outside the fence" might not receive the appropriate attention.

United Kingdom	ATEX risk assessment is one of the inputs to Seveso risk assessment, but will also cover events that would not be major accidents Other occupational safety risk assessment may also be an input to Seveso risk assessment and help identify causes and initiating events The same hazard ID process (e.g. HAZOP) will cover all types of events: occupational and major accident The UK approach of proportionality aims to treat each event according to the level of risk	Top down HAZID (e.g. PHR) is often used for Seveso, focusing on major accident events and will miss occupational accidents A reason for this is that it can be less time-consuming to start fresh for Seveso rather than going back through HAZOP records, but the continuum from occupational to major may be lost (does this matter?) Risk assessments are carried out for slightly different purposes. May lead to duplication. e.g. both COMAH (Seveso) and DSEAR (ATEX) require assessment of fire and explosion hazards and conclusions about ALARP. DSEAR is more concerned with onsite risk and COMAH with on and off-site societal risk. Considering both together is more holistic, but they may be done separately due to slightly different outputs/reporting requirements. There is conflicting evidence as to whether concentrating on occupational safety management will address all the initiators of major accidents. Probably, it is the process-related occupational accidents that can be precursors of major accidents.
Netherlands		The risk assessment procedure is not similar for external risks and ATEX risks. The risk assessment procedure for ATEX risks starts most of the time from predefined distances where there can be an explosive atmosphere. It is assumed that the probability of ignition is 1. For the determination of external risks the physical effects are calculated in much more detail and the probabilities of the succeeding events are taken into account. When scenarios and the corresponding failure rates are straightforwardly based on the Purple Book, as a consequence the differences between similar companies are not recognisable anymore. The calculation results (iso-contours and fN-curves) are mainly used as an environmental and county planning instrument and less to determine the safety level of alternative conducts of processes. Strict application of the Purple Book guidelines do not show differences in the safety level of one company compared to a similar other company.

8. Links between occupational and external accident risk assessment

The aim of this chapter is first of all to determine if there is a link between occupational and external risk. Firstly existing links are addressed. Secondly the conditions to maintain existing links or to achieve coherence between these two identified types of risks are brought into vision.

8.1 How and where are both types of hazards tackled?

The word "link" may be interpreted in various ways. Here a link is presented by answering the question: "How and where are both types of hazards tackled?" A link between occupational and external risk can be found in the Safety Management System (SMS) requirements of the SEVESO guideline. The Safety Management System (SMS) should address of the following 7 elements:

1. organisation and personnel
2. identification and evaluation of hazards
3. operational control
4. management of change
5. planning of emergencies
6. monitoring performance
7. audit and review

The identification and evaluation of hazards to be achieved in the framework of the SMS cannot (should not) be limited to external risks. It should consider all (loss of containment) scenarios that may "*lead to serious danger to human health and/or the environment, … inside or outside the establishment*". For both types of hazards the so-called Deming cycle of planning, doing, checking and acting generally has to be followed.
So, answering the question if there is a link between occupational and external risk, it is obvious that policies, procedures, instructions and standards, that are part of the company's management system, should generally concern both occupational and external risks.

8.2 Are occupational and external hazards related to each other?.

Here the word link is interpreted by answering the question: "Are occupational and external hazards related to each other?" It is not proven that a high level of occupational safety is a guarantee that no major accidents will happen.
Occupational risk or safety in CPI includes all aspects present in general (industrial) activities, like tripping, falling and machine or tool related accidents; but also accidents with chemical substances. External risk or safety is always related to accidents with chemical substances. In general effects of non-chemical accidents are limited to on-site personnel.
Major accidents often happen due to a combination of factors that have not been foreseen. This is usually not the case for occupational accidents. They are usually much more trivial and happen more often.
However, these kinds of accidents can be the start of a chain of events eventually causing a release of chemicals with an off-site effect. Therefore it is generally considered to be beneficial (as well as best practice) if a company does focus on identifying and controlling health and safety hazards, learns from accidents and takes appropriate measures to prevent re-occurrence

(in other words: the company executes and improves the safety management system). Those companies act according to the best available safety guidelines at the moment. It goes without saying that inspecting, auditing and reviewing all elements related to the major accident scenarios are indispensable as well.

8.3 Conditions for coherence between occupational and external safety

An important element in the Seveso guidelines is inspection: authorised bodies that are inspecting both organisational and technical aspects. In nearly all countries, involved in this survey, there are different authorised bodies for occupational and external safety. This applies for policy making and legislation as well as for regulations and enforcement. Only in the United Kingdom, much is in the hand of the Health and Safety Executive.

The SEVESO Directive appears to create some confusion about the definition of “major accident” where it speaks about a serious danger <u>inside</u> or <u>outside</u> the establishment. It has been reported that in a number of countries inside dangers are not taken into account in the reports in the framework of the Seveso legislation.

8.4 Conflicts between occupational and external risk

For chemical accidents in general there is an increasing severity range from occupational to external risk. Small leaks from flanges, drains or instrument lines can be dangerous for a plant operator; however this will rarely effect the off-site population. Large releases will, before ‘leaving’ the plant and exposing the nearby residential area to dangerous concentrations, also expose the on-site operator to an even higher concentration. Some measures which can be taken or conditions which are present have opposing effects on occupational (on-site) and external (off-site) safety. For instance, locating an installation with a highly toxic substances inside an air tight building is a good protection measure for the population living in a nearby residential area. The operator working in this building, however, will be exposed to higher concentrations in case of a release compared to the same installation being outdoors. On the other hand, whereas the on-site personnel in most cases is equipped with personal protective equipment (PPE, like gasmasks) or working in an overpressure and explosion protected control room, the general public only can shelter indoors or can evacuate.

8.5 The situation in Europe

The countries in Europe have many points in common regarding their safety and risk policy, regulations and enforcement for the chemical process industry. This is of course because this industry, with many multinational companies, has the same kind of processes all over the world and is handling the same kind of chemical substances. At the same time, however, there are large differences. Occupational safety is not part of European regulations, and therefore dealt with by all countries individually. But even for external safety, for which the so-called SEVESO Directive is in force since the late eighties, there are many differences. This is still in line with this Directive, because it is mainly goal-setting.
In nearly all countries, involved in this survey, occupational safety and external safety are dealt with by different organisations. This applies to policy making and legislation as well as to

regulations and enforcement**.** Only in the United Kingdom, much is in the hand of the Health and Safety Executive.

8.5.1 France

Occupational and major accidents are dealt with separately, by separate organisations. The scenarios to be considered are not identical: for SEVESO, the scenarios of major accidents have to be considered, but for ATEX, every scenario where a worker might be injured has to be considered and, generally, it does not correspond to a major accident scenario,
In order to comply with SEVESO regulation, for a building inside which a gas or vapour explosion has to be considered, a determinist point of view would impose to protect the building by venting; however, in case of an explosion inside the building, the workers would be injured or killed. A preventive measure (e.g. a well maintained and secured ventilation) should be preferred because it would be efficient both for workers safety and for building integrity

8.5.2 United Kingdom and Netherlands

The safety management system is seen as providing a link between occupational accidents and major accidents. In cases where both would have the same root causes (e.g. when the occupational accidents would be as a result of the process rather than due to slips and trips), a good SMS would be expected to reduce the likelihood of both occupational and major accidents.

8.5.3 Germany

The connection between SEVESO II and ATEX is the definition of a major accident as a major emission, fire, or explosion.
Measures to the explosion protection are also measures to avoid major accidents. Therefore the hazard analysis is **a part** of the safety assessment of a SEVESO installation with regard to the explosion protection in Germany. In addition also all other fields of occupational safety (hazard analysis) must be judged.

8.5.4 Greece

The Ministry of Employment and Social Security is one of the Competent Authorities in Greece required to review and approve the Safety Analysis reports submitted by installations subject to the SEVESO Directive. Since, this ministry is the sole responsible actor for occupational safety its involvement represents a link between external and occupational risk management in Greece.
Furthermore, the Safety Management System for Major Risks is usually based and represents an extension of the Occupational Health and Safety management systems in Seveso installations. This represents a second link between Major Hazards and Occupational Safety.

9. Proposed recommendations

The SHAPE RISK project is focussed on the development of integrated risk management in the process industry throughout Europe. Work package 2 deals with the continuity of risk management from workplace accident to major accident. As can be seen from the previous chapters there is a large variety in methods and criteria used as well as institutions involved in the various countries that have been studied, all with their own specific pros and cons regarding the possibilities for integrating occupational and external risk management. Below are a number of difficulties that were found to be common to all countries studied, followed by recommendations that were identified to address these problems. After this some good working practices, or suggestions identified during the investigations are given. The analysis is first of all based on the previous chapters but also on the discussions during the workshop in November 2004 in Paris.

9.1 Difficulties

1. In nearly all countries involved in this survey, occupational and external safety are dealt with by different organisations**.** This applies for policy making and legislation as well as for regulations and enforcement. As a result industry is confronted with larger administrative overhead, higher costs, longer permission.

2. Risk assessments are carried out for slightly different purposes. This may lead to duplication.

3. Measures taken to protect the workers may have an adverse effect on the population outside the fence and vice versa.

4. In the SEVESO Directive there appears to be lack of clarity about the definition of major accident where it speaks about a serious danger inside or outside the establishment. In most countries inside dangers are not taken into account in the reports in the framework of the Seveso legislation.

5. There is a lack of safety knowledge in the small and medium-size enterprises (SME's).

6. At present information about risk assessments is quite scattered and the availability in the surveyed countries, for others than the experts in the field, is very limited.

9.2 Recommendations

1. Encourage a common approach between authorised bodies for occupational and external safety.
   Occupational and external risk in chemical companies is partly linked to the chemicals in process or storage. The effects of accidents involving chemicals may be limited to on-site personnel but may also extent to the off-site population, depending on the amount released and the nature of the chemical (e.g. the toxicity). Several stakeholders are involved in dealing with this risk. Inside the company the management and the employees deal with both occupational and external risk. At the side of the authorities, in

most countries in this survey, there are different bodies for occupational and for external risk. If both risks are resulting from the same scenarios (accidents with chemicals) it would be beneficial to have two closely co-operating bodies. One authority will lead to a more continuous treatment of occupational and external risk.

2. Risk assessments for both process-related occupational and external safety should be joined in one report to avoid duplication, as for an important part one deals with the same scenarios.

3. The defence lines against possible accidents can and should be made consistent. Beneficial and adverse effects of proposed safety measures should be assessed on both the workforce and the public.

4. The definition of 'major accident' should be clarified with respect to its use inside or outside an establishment.

5. More guidelines by authorities regarding the preferred systems and methods would be beneficial, especially for the SMEs.

6. Improve the availability of information and know-how.
The information about risk assessment methods and data (reliability, failure frequencies, effectiveness of safety barriers, etc.) must be available to all stakeholders. In the European framework it would be very helpful to have the information broadly and generally available.

9.3 Other suggestions

- *(semi) quantitative methods give directions for improvement;*
Most countries, in this survey, apply (semi) quantitative methods for occupational risk whereby the risk is presented in the form of a risk matrix. This representation enables ranking of the risk, comparison of the risk against (semi) quantitative risk criteria, and prioritising of the various risk reduction measures.
In contrast to the estimation of occupational risk, countries in this survey apply less frequently quantitative methods for the estimation of external risk.

- *methods must be proportionate to risk;*
Complexity of risk determining methods must be proportionate to the risk thus limiting the burden to both companies and the authorities involved. The use of the methods is encouraged when the methods are not 'bigger' than the risk.
In most cases the size of the company in combination with the nature and the amount of the chemical substances in process or storage gives a good indication of the size of the risk. A preselection step can be used to make a choice of available methods.

9.4 Barriers that can compromise the implementation of the proposed recommendations

The implementation or application of the recommendations and suggestions mentioned above may not be straightforward.

To have one authority responsible for occupational and external risk, related to chemical accidents, and having one safety report, may take a long time to realise, as large organisations will need to be reorganised. A way of starting the process is to keep the existing organisations and make them work together more closely and make one of them responsible for the overall chemical risk.

The process for improving the methods or even more for changing the used methods can also take a long period of time. Changing methods and tools will almost always also change the results of the risk assessments to some extent. With the many stakeholders involved, it may be difficult to reach agreement. It may cause conflicts with existing policy on occupational risk and external risk, or may affect results that are used for land-use planning.

Sharing information is only a matter of co-operation. However, at the European level, it can take much time to make it work.

10. Research and development needs

At present separate methods for treating occupational and external risk exist in most countries. To make it possible to treat both kinds of risk in a continuous way, new methods must be developed. Logically these methods take as starting point the common scenario (analysis) for chemical accidents which can lead to both occupational as well as to external risks.

A main item for future developments is a shared information basis and structure. Information can be brought together by several (key) organisations in the field. The information ideally includes the technical risk aspects as well as the safety management and political aspects.

The big chemical industries have the knowledge and the resources to meet the legal requirements regarding occupational and external safety. This is not self-evident for the small and medium enterprises. Therefore the development of an automated expert system for SME's with condensed information and based on the needs of the SME's is strongly suggested.

11. Conclusion

In most countries different authorities are responsible for occupational and for external risk. Also, linked to this, different methods are in use for both kinds of risk. To achieve a more continuous assessment for occupational and external risk both involved authorities must be combined or work together closely.

Methods used should be harmonised in such a way that they can be used for the assessment of both occupational and external risk resulting from loss of containment of dangerous substances.

In the SEVESO Directive there appears to be lack of clarity about the definition of major accident where it speaks about a serious danger inside or outside the establishment. In most countries dangers on-site are not taken into account in the reports in the framework of the Seveso legislation. The definition of 'major accident' should be clarified with respect to its use inside or outside an establishments.

The big chemical industries have the knowledge and the resources to meet the legal requirements regarding occupational and external safety. This is not self-evident for the small and medium enterprises. Authorities should give better guidelines regarding the preferred systems and methods that should be used for risk assessments would be beneficial, especially for the SMEs .

Much knowledge in the field of risk assessment, both for occupational and for external risk is available in Europe. However the information is much scattered and not easily accessible for everyone. Therefore it would be beneficial if a shared basis of information with easy access could be made available.