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DELIVERABLE

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SEVENTH FRAMEWORK PROGRAMME

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Abstract

The harmonization and the generalization of national approaches to risk assessment on non-nuclear critical infrastructures have been emphasized in the European Union in order to standardize guidance and increase safety levels in terms of risks emitted by natural hazards and critical infrastructure.

This report gives a literature survey about national regulations and guidelines used in European countries. Available European documents are examined. Conclusions and advised approaches to conduct risk assessment are discussed in additional chapters.

National and European documents dealing with the six types of critical infrastructures investigated in the STREST project are then introduced and examined.

Keywords: National standards and guidelines stress tests, natural hazards, literature survey, European Union

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1 Introduction

A critical Infrastructure (CI) is an asset or system, which is essential for European society and environment. Because of the CI's high integration and modern Europe's dependencies, a failure of a superregional CI facility could cause large-scale effects.

In the European Union (EU), measures are taken to increase the protection of society and environment. Among European campaigns, the STREST project develops a harmonized approach for stress tests of European CIs.

This report is one of four tasks (Task 2.2) defined in the work package WP2: "State-of-the-art and lessons learned" of the STREST project. It gives a survey about state-of-the-art methods and guidelines in terms of risk assessment[1] in European countries and in the entire EU. Aggregations are based on publicly available documents, which are issued mainly by national governments, the EU and the European Commission.

In chapter 2, the "European Programme of the Protection of Critical Infrastructures" and other European guidelines and standards are examined. The way different individual European countries deal with risks related to CIs is examined in chapter 3. Chapters 4 to 7 deal with more specific standards for the types of CIs as defined in STREST. Conclusions are drawn in chapter 8.

[1] With reference to the title of this report it has to be noted that the focus is set on risk- rather than hazard-assessment. The authors consider hazards to be included in risk assessment. WP3 of STREST, "Integrated low probability-high consequence hazard assessment for critical infrastructures", deals with hazard assessment.

2 European standards and programmes dealing with risks

Critical Infrastructures (CIs) provide essential goods and services for modern society; they are highly integrated and have growing mutual dependencies. Recent natural events have shown that cascading failures of CIs have the potential for multi-infrastructure collapse and widespread societal and economic consequences. Moving toward a safer and more resilient society requires improved and standardized tools for hazard and risk assessment of low probability-high consequence (LP-HC) events, and their systematic application to whole classes of CIs, targeting integrated risk mitigation strategies. Among the most important assessment tools are the stress tests, designed to test the vulnerability and resilience of individual CIs and infrastructure systems. Following the results of the stress tests recently performed by the EC for the European Nuclear Power Plants, it is urgent to carry out appropriate stress tests for all other classes of CIs. Measures taken are promoted and European Guidelines are defined in the following.

2.1 PROGRAMME ON THE PROTECTION OF CI

In December 2008, the European Commission issued the directive (EC, 2006) introducing the principles of the so-called "European Programme for Critical Infrastructure Protection" (EPCIP). Different concepts on risk evaluation and risk analysis together with risk assessment of CI are proposed in the guideline (EC, 2006). It is stated that the major effort in risk management (especially in periods after an occurrence of an extreme event) has to be conducted by public participation. Thus, the private and industrial sector has to be fully incorporated into any measures introduced by National Governments and the EU, which deal with risks and hazardous events and their possible consequences.

2.2 DETERMINATION AND IDENTIFICATION OF CI

(EC, 2008a) is the subsequent law act, which was introduced in 2009. The latter is the European Guideline on how to assess, categorize and evaluate European CI (ECI). A differentiation is made between European and National Critical Infrastructure. ECI has cross-border influences on society and environment. The report connects different measures to increase the protection of ECI, among which terrorism is defined as a major threat. Additionally, the vulnerability of CIs to natural hazards is examined and discussed. (EC, 2010f) is the homepage introducing the programme.

(EC, 2008a) is introduced among a series of working papers as a guideline to determine and identify safety of ECI in a step-by-step approach. Fig. 2-1 shows this step-by-step approach for the identification of ECI, taken from (EC, 2013a).

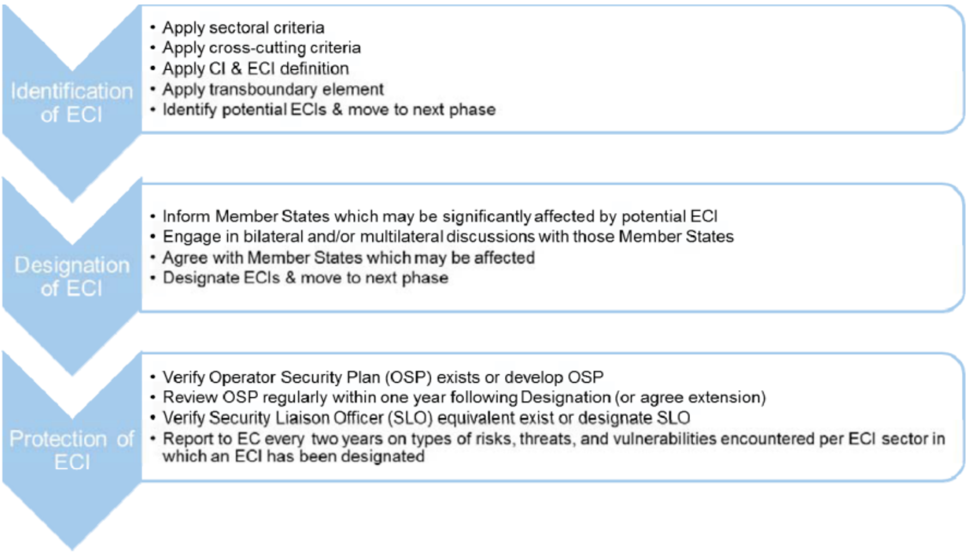

Fig. 2-1 Main points to classify European CI

Additionally, (EC, 2008a) is introduced to assist national authorities in their sectorial plans in a first step to increase the quality level of measures under the context risk assessment in the fields of energy (electricity, oil, gas) and transport infrastructures. These measures require the definition of general operation plans, emergency plans and experts responsible for individual CIs. These experts should enforce the cross-national risk assessment and risk management. Communication between involved stakeholders of CIs, between national governments and with the European Union is enforced every two years. Confidentiality is a principal demand to ensure respectable discussion. Risk assessment methods and risk classification methods have to be introduced. It is stated in (EC, 2008a) that the definition of a general risk assessment guideline is hard to find for the entire European Union. Thus, responsibilities are also distributed among individual countries.

(EC, 2008b) is a proposal, in which details about the implementation of an information network regarding Critical Infrastructures (Critical Infrastructure Warning Information Network CIWIN) are defined. A discussion of multi-hazard events is introduced: E.g. cascading failures of critical structures. This information network should enforce risk management, especially after the occurrence of hazards.

2.3 IMPLEMENTATION AND IMPROVEMENTS

In (EC, 2013a), the previously stated preliminary findings of the articles (EC, 2008a) and (EC, 2008b) are recapitulated. The majority of Member States have implemented the provisions of (EC, 2008a). Austria, Estonia, Finland, The Netherlands and the United Kingdom came to the conclusion that no legislative changes were required. (EC, 2013a) shows the possible application of the Directive (EC, 2008a). One drawn conclusion, which has been drawn is that the Directive has not necessarily increased safety levels: The majority of CIs have been identified already before the Directive has been introduced. The databases presenting individual CIs could be incomplete, e.g. because they could neglect CIs such as cross-border networks. Thus associated cross-border risks are not analysed, which however can result in major risks for affected countries. The biggest stated improvement mentioned in (EC, 2008a) is the increased awareness about protection of CIs in Europe because of the open discussion.

The general European approach to risk assessment is proposed in (EC, 2013a) and earlier in (EC, 2012): These reports discuss the identification and classification of threats. The identification of vulnerabilities and theoretical impacts on CIs are evaluated. Importantly a "sectorial approach" (every sector is treated independently) and a "system approach" (CIs are treated within interconnected networks) are introduced in (EC, 2013a). (EU, 2014) is a follow-up report in terms of an European International Security Strategy investigating how the resilience of a CI can be increased.

2.4 REVISIONS

(EC, 2013b) introduces a revised and more practical European Programme to increase the resilience of CI. The assessment of the interdependencies of different types of CI are discussed. The implementation of the programme in the European Member States is discussed in (EC, 2013b). Similar to (EC, 2013a), the application of the European Programme to protect Critical Infrastructures has been limited in practical terms. Thus, similar to the approach chosen in STREST, four types of CI (The European Organisation for the Safety of Air Navigation: Euro Control, the global navigation satellite system Galileo, the European Electricity Transmission Grid and the European Gas Transmission Network – "The Four") are investigated more specifically. According to (EC, 2013b), hazard and risk assessment methodologies, which can be used to deal with low-probability but high-consequence events (LP-HC) should be developed. The idea is to design "Stress Tests" for critical infrastructures. In 2014, the roadmap of the programme will be defined.

(EC, 2013c) gives an overview of disaster risks, which the European Union has to face. Natural hazards and their treatment in different European Member States, which are also discussed in the current STREST project, are examined and investigated. Thus (EC, 2013c) gives an important overview of risks. Risk management and the approaches chosen in national standards to deal with these natural hazards, are not discussed.

In (EC, 2010d) the cooperation and the cross-border connection of risk assessment and risk management in the European Union is discussed. The idea of the programme is to help Member States in decision-making and to provide instruments to conduct coherent and consistent risk assessment. Extensive public information is mentioned as an important tool to increase public awareness.

2.5 EUROPEAN STANDARDS

In a series of documents issued by the European Commission dealing with risk assessment and management of ECI, (EC, 2012) is the latest European Directive regulating the treatment of chemical substances in the European Union. The first Directive (EC, 1982) with the working title "Seveso" has been introduced to evaluate consequences caused by dangerous substances after the "Seveso Accident" in Italy, 1976. This regulation was then replaced by Seveso II (EC, 1996) and extended with the regulation (EC, 2003), from which Seveso III (EC, 2012) emerged. The main objectives of the Seveso Guidelines are firstly to prevent major accidents involving dangerous substances and secondly to limit accidental consequences for man and for environment. Cascading failures are dealt with in terms of "Domino Effects".

85 per cent of accidents reported are caused by management failures, (Porter, 1999). Thus, (EC, 2012) proposes measures to increase management approaches. (Porter, 1999) gives further proposals on the application of this European Directive.

(EC, 2000) establishes a framework in the field of water policy. Later, the directive (EC, 2007) has been introduced to analyse flood risk. The guideline intends not to reduce the risks of floods, but to increase the quality of how consequences are dealt with: E.g. financial support of affected people are proposed, flood hazard maps are defined and the identification of different flood scenarios are promoted. Emergency plans and in-plant measures to respond to dangerous events have to be defined by Member States.

In (EC, 2010a), an all-hazard approach to risk management is discussed in order to improve coherence and consistency among the risk assessments taken by European Member States. (EC, 2010b) is a staff working paper of the European Commission to develop risk assessment and mapping guidelines for disaster management. Proposed measures should consider work applied on national level to ensure a better comparability between Member States. Table 2-1 is taken from this article. It is a clearly designed summary of theoretically possible natural and industrial disasters, to which ECI are subjected. Thus the figure assembles the principal European Guidelines (the Eurocodes) to treat natural impacts.

According to the European regulations, the Eurocodes are used to define actions on structures (EN1991, 2014). These actions (e.g. snow, flood or earthquake loads) are identified in national appendices and location specific regulations. It is a national matter to determine them. The seismic design of buildings has to follow Eurocode 8 (EN1998, 2014).

Table 2-1 Eurocodes relevant for different types of natural and industrial disasters

Type of disaster	Technical / normative framework
Forest fires	Eurocode 1 (actions on structures) defines protective design measures against fire for buildings made of various materials (steel, concrete, wood, masonry)
Ground movements	Eurocode 7 defines calculation and design rules for stability of buildings according to Geotechnical conditions of construction site (XP ENV 1997, PR EN 1997-2, ENV 1997-3)
Earthquakes	Eurocode 8: EN 1998-1 (general rules, seismic actions), EN 1998-3 (assessment and strengthening of buildings), ENV 1998-4 (reservoir, pipes), EN 1998-5 (foundations, structures), EN 1998-6 (masts, towers…)
Storms, Hurricanes	Wind resistant design of buildings is covered by Eurocode 1 - EN 1991-1-4
Cold waves	Eurocodes cover protection against cold and snow
Heat waves and drought	Eurocode EN 1991-1-5 includes design to resist heat waves Partly covered by Eurocode EN 1997-1-1 (Geotechnics)
Industrial and technological hazards	Eurocode 1 (EN 1991-2-7) also defines building design rules against explosions
Marine pollution and oil spills	Technical norms for vessels

(EC, 2010b) gives proposals for risk identification, risk analysis and risk evaluation and importantly a proposal on how to deal with uncertainties and the cross-border dimension of risk assessment on the European Level is made. Measures to prevent in principle all natural and man-made disasters both within and outside the EU are discussed. Only armed conflicts, terrorism and malicious threats are excluded. In (EC, 2010c) risks and threats related to forest fires are examined. The Eurocode 8 (EU, JRC, 2010e) is considered to assess building designs for seismic risks. It is stated in (EC, 2010b), page 6, that risk classification is not addressed in previously mentioned guidelines.

The ISO 31000 (ISO, 2009) is a library of standards dealing with risk management. It is supervised by the International Organization for Standardization (ISO, 2009). The purpose of the ISO 31000 is to give a principle and general guideline on risk management.

Germany, Austria and Switzerland discuss in their cooperation programme "D-A-CH" risk analysis for civil protection in reports, e.g. see (D-A-CH, 2012). Switzerland, although not a European Economic Area (EEA) member, is invited to join the activities under CIP, see (EC, 2013a). Bilateral agreements exist, which enforce the cooperation between responsible federal institutions in the different countries.

(EC, 2012), "Risk assessment methodologies for Critical Infrastructure Protection. Part I: A, state of the art" has been issued in 2012 by the European Commission / JRC. This report covers relevant state-of-the art methods and provides additional information on risk assessment methods. Methods cited in this report are briefly introduced in the Appendix A: "Risk assessment methods".

2.6 EUROPEAN & INTERNATIONAL PROJECTS

The European Union has financed and has undertaken a number of projects of the type (ENV, 2014) and (INFRA, 2014), which have dealt with topics related to STREST.

(SYNER-G, 2012) is an EU-FP7 project, which is meant to identify seismic vulnerabilities and risk analysis for buildings and regions in the EU. Induced seismicity is examined in (GEISER, 2013). (SERSCIS, 2011) has been introduced to develop adaptive service-oriented technologies for creating, monitoring and managing secure, resilient and highly available information systems (e.g. CIs), so they can survive faults, (e.g. from natural events, accidents and malicious attacks). (REAKT, 2013) is an EU-FP7 project dealing with "Strategies and tools for Real Time Earthquake Risk Reduction". (NERA, 2014) is introduced with the title "Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation". The EU-FP7 programme (MATRIX, 2013), "New Multi-Hazard and Multi-Risk Assessment Methods for Europe", deals with interdependencies of natural hazards and phenomena in order to avoid treating such events only individually.

(SHARE, 2013) harmonizes the treatment of seismic hazards in Europe. It has the main objective to provide a community-based seismic hazard model for the Euro-Mediterranean region. The first, ever, completed state-of-the-art hazard model for the European region is introduced. The resulting hazard map serves as input for risk assessment and mitigation policies (e.g., earthquake resistant designs), which will be later used for revisions of the Eurocode 8 (EU, JRC, 2010e). SHARE is based on a time-independent probabilistic approach. Further details on related EU projects are given in D2.4, "Report on lessons learned from on-going and completed EU projects", (STREST-D2.4, 2014).

The European Union introduced the "Floods Portal" (JRC, 2011), which brings together information on river floods and flood risks in Europe. Additionally, (JRC, 2014) has been introduced as a flood alert system. A publicly available map is used to warn against flood hazards in a constantly updated process. (EC, 2009), "Integrated Flood Risk Analysis and Management Methodologies" has been introduced with the intention to consider flood risks as a combination of hazard sources, pathways and the consequences of flooding on people, property and the environment. (CRUE, 2009) has been funded by the EU to increase the cooperation of national governments. With this harmonization, best practices and gaps should be identified. For additional information, (EC, 2014) is the website introduced by the European Commission, which assembles different projects analysing flood risks in the EU.

(SSHAC, 1997), the "Senior Seismic Hazard Analysis Committee", has issued recommendations on the application of probabilistic seismic hazard analysis. It provides guidance on the systematic introduction of expert opinions and the intrinsic uncertainties in a probabilistic hazard assessment. Because of the SSHAC reports relevance to nuclear industry, further details are given in D2.1, "Lessons learned from stress tests of nuclear facilities", (STREST-D2.1, 2014).

3 National standards and programmes dealing with risks (selected countries)

In the Appendix A, methods to apply risk assessment, which are cited in this chapter, are briefly described: Hazard and operability study (HAZOP), Failure mode and effects analysis (FMEA), Fault-tree analysis (FTA), Event-tree analysis (ETA) and Risk matrix (RM).

The incident affecting the Italian town Seveso in 1976 initiated the first directive addressing large scale chemical hazards, carrying this town's name, (EC, 1982) that started the process of systematic analyses of risks associated with processing, storing and transporting large quantities of dangerous substances. Countries followed various approaches, depending on local circumstances. Some are detailed, some others are coarse; some are quantitative, some others are qualitative; some are very prescriptive, others allow a lot of freedom in the choice of methods to be applied.

In the paragraphs below, an overview is given of the way the "Seveso" directive (which has evolved to "Seveso-II" (EC, 1996) and Seveso-III" (EC, 2012) over the years) has been implemented in a number of European countries (derived from (EUR, 2006)). In the Seveso directives the volumes and types of substances determine the potential risk level. Two threshold values are used for each substance. For volumes above the lower value, but below the upper value the 'lower tier' requirements apply. For volumes above the upper value, the 'upper tier' requirements apply, which are more extensive than the lower tiers requirements.

Despite their differences, if a systematic approach is used, for all countries a risk analysis for chemical hazards will comprise (at least parts of) the following phases:

1. Identification of hazard: The parts of the installation, which are of importance with respect to safety including mapping of the origin and causes of possible accidents as well as the quantities and properties of chemicals used. This phase may result either in direct measures to reduce the risks) or they have to be found in (a list of) scenarios that are to be considered in more detail (steps 2-4 below).
2. Analyses of accident scenarios: How a cause can result in the release of the dangerous substance (usually expressed as Loss of Containment – LOC) and what could be the consequences.
3. Analysis of causes and consequences in which the accident scenarios are analysed more thoroughly:
    - o How likely is such an LOC to occur? Typically two approaches are distinguished:
        - ▪ a probabilistic approach, in which the likelihood of each LOC is assessed (e.g. expressed as the expected number of occurrences per year or frequency) and
        - ▪ a deterministic approach, in which LOCs are either included as possible or dismissed as too unlikely for further consideration.

- o How severe are the consequences? Who or what is affected (human health, environment)?
- o Combination of causes and consequences to evaluate the total risk: The final evaluation of the risk includes a ranking of the scenarios considered. The probabilistic approach will define the risk as the combination of the frequencies and the consequences. The deterministic approach is based on the possible consequences of included LOCs.

4. Decide which action should be taken to deal with the risk.

All these steps can be performed in a qualitative, quantitative or semi quantitative way. Usually differences exist in the extent of quantification of the likelihood of an LOC. In a qualitative assessment likelihood might be expressed in terms of 'quite likely' or 'this has never happened in a similar process'. Evidence is given through casuistry of accidents in the past (databases) or through engineering judgements. The consequence assessment however is usually quantified, especially for scenarios with the potential of affecting people or the environment offsite.

In all cases, the eventual conclusions are derived by a combination of likelihood and consequence. This combination results in an expression of risk (qualitative, semi-quantitative or fully quantitative). This 'risk figure' forms the basis for decision making about acceptability of the level of risk, which will depend on the objective of the study and relevant stakeholders.

Objectives, either in isolation or in combination, could be:

- Licence application (LIC);
- Determination and evaluation of risk reducing measures (RRM). Preventive measures reduce the likelihood of a LOC and mitigation measures reduce the severity of the consequences;
- Land-use planning (LUP);
- Emergency response preparation (ERP).

The various objectives logically lead to differences in the nature and the extent of risk studies. The following stakeholders can be identified:

- Competent authorities, for the purpose of environmental permission;
- Competent authorities, for the purpose of fulfilling safety report obligations, e.g. as per "SEVESO requirements";
- Emergency Response organisations, for the purpose of response preparation;
- Regional planning authorities, for the purpose of decision making on land-use planning in an area with major hazard industries or dangerous goods transport;
- Installation owners, for the purpose of identifying priorities in risk reduction or for cost–benefit analysis of different risk reduction options.

In the following paragraphs an overview is given of the risk methods used in a number of countries (largely based on (EUR, 2006)). It is a limited selection as the methods that were designed and implemented by the 'early adapters' of the 'Seveso Directive' largely served as a template for countries that developed their methods in a later stage, when they became a member of the EU.

In addition risk methods in which particular mention is made of CI are also mentioned.

The following regions and countries were selected:

- Western Europe: The Netherlands, Belgium (BE), United Kingdom (UK), Germany (DE);
- Southern Europe & Mediterranean: France (FR), Spain (ES), Greece (GR);
- Northern Europe / Scandinavia: Finland (FI).

Additional information on Israel and the USA are given.

3.1 THE NETHERLANDS

The Netherlands have developed one of the most extensive and fully quantified probabilistic risk assessment (QRA) methods present under the Seveso directive(s). It is also one of the most prescriptive. Installations, types and frequencies of LOCs, calculation methods, risk acceptance criteria and even the computer programme to use are prescribed. This situation has developed over two decades, mainly driven by the desire to obtain reproducible and comparable results for land-use planning purposes.

A QRA is required in the safety report for each of the higher tier Seveso sites. Even for non-Seveso installations, competent authorities may require a QRA to be carried out as part of a permit procedure for new installations or for urban developments.

The methods to be used for modelling and quantifying the risks associated with dangerous materials are described in what has become known as “the coloured books”. They were issued by the national “Committee for the Prevention of Disasters” (CPR). These ‘coloured books’ form the standard for QRAs in The Netherlands and are widely used in countries abroad as well:

The Red book (CPR-12, 1997) describes statistical methods as an aid to determine LOC frequencies.

The Yellow Book (CPR-14, 1997) presents recommended models for physical effect calculations for the release, evaporation and dispersion of hazardous materials and for assessing thermal radiation due to fire, overpressures due to explosion and exposure to toxic dose.

In the Green Book (CPR-16, 1992) one finds models for assessing the potential damage due to exposure to the mentioned effects.

The Purple Book (CPR-18, 1999) gives the standardised procedures for a QRA in The Netherlands, including reference scenarios for equipment on industrial sites and for transport of dangerous goods by road and rail and over inland waterways, and their frequency of occurrence.

Two types of risk acceptance criteria are in place, applicable outside the plant’s boundaries. These refer to zoning distances that should be observed for specific activities: Individual risk or Location specific risk (LR) and Societal Risk (SR) (I&M, 2012).

Locational risk:

The annual frequency of a hypothetical person being lethally affected by the consequences of possible accidents during an activity with hazardous materials, e.g. a chemical plant or transport activities.

This risk indicator is a function of the distance between the exposed person and the activity, regardless whether actually people are living in the area. Locational risk (LR) is presented in contours on maps of the surroundings; the contours connect locations of equal LR. No (limited) vulnerable objects or installations are allowed in areas where the locational risk is more than 10-6/yr. Vulnerable objects are dwellings, medical centres, hospitals, schools etc. Limited vulnerable objects are offices, shopping malls, commercial activities etc.

Societal risk:

The cumulative frequency that a minimum number of people will simultaneously be killed due to possible accidents during an activity with hazardous materials.

Here, the actual presence of people in the surroundings is taken into account. Results are presented as a graph in which the cumulative frequency is plotted against the number of lethally injured people.

A maximum allowed societal risk standard does not exist; only a guidance value has been defined. This guidance value means that the authorities will allow the proposed activity if the societal risk is below the guidance value. The authorities are allowed to accept activities with higher societal risks than the guidance value or activities causing an increase in the risk in certain circumstances. In such a case the authorities have to balance the pros and cons of the proposed activity. Fig. 3-1 presents an example of a societal risk (blue) curve and the guidance value (red).

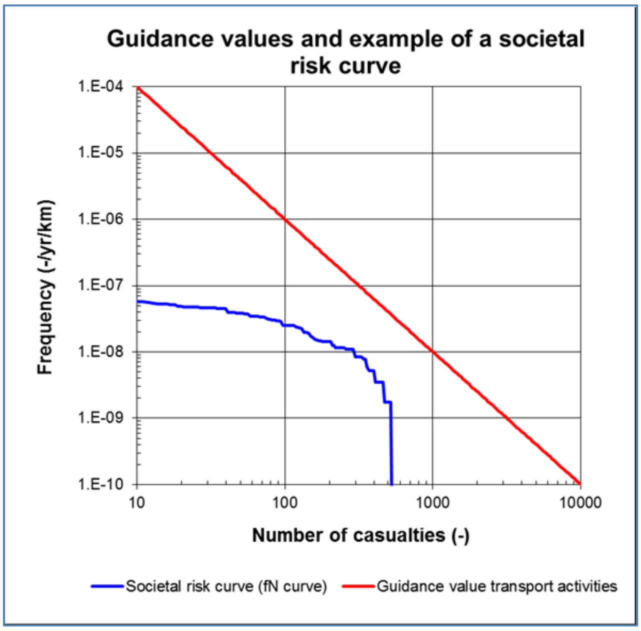

Fig. 3-1 Example of societal risk curve and guidance value

For ‘Seveso Sites’ methods the models and criteria to be used have been condensed in a mandatory computer programme.

For certain types of enterprises fixed safety zoning distances between the installation and the populated surroundings have been set and no QRA is required anymore. These zoning distances are also risk based and they reflect the (average) distance for location specific risk LR = 10^{-6}/year.

3.2 BELGIUM

Belgium is a federal state where regulations and their implementation are different for the two regions Flanders and Walloon. The Flemish approach is strongly related to the Dutch one (probabilistic). The Dutch CPR guidelines are also recommended as standard in Flanders. For probability and frequency assessment, the Flemish authorities have developed their own set of figures (AMINAL, 2005).

For the acceptance criteria for location specific risk three types of surroundings are distinguished: the boundary of the establishment, the boundary of the industrial area and the location of vulnerable objects. Moreover, distinction is made in the tolerance limits between existing situations and new ones.

3.3 UNITED KINGDOM

In the United Kingdom a quantified risk assessment is required in safety reports according to Seveso-II (COMAH, 2013), The risk analysis approach is primarily a probabilistic one. The procedures for a QRA are not very strictly prescribed, though the competent authority, the Health and Safe Executive (HSE) (HaSE, 2013), has developed several guidance documents for assisting the risk analysts ((HSE, 2001), (HSE, 2002), (HSE, 2003)).

The QRA procedure and phasing is one according to ‘proportionality’, which means that the extent of detail of a QRA shall be proportional to the risk generated and/or to the complexity of the process / installation in question. In practice, this means that for relatively simple situations a deterministic or even qualitative approach is followed. If then no (external) hazard is expected, the procedure of risk analysis is satisfied. However, in cases where off-site hazard may occur or high societal concerns exist, a more in-depth analysis of scenarios, their causes and mitigating measures is required. Quantified probabilistic assessment of these issues is then required. In decision-making, ALARP ("as low as reasonably practicable" - The residual risk shall be as low as reasonably practicable, thus a further reduction of the risk would be disproportional costly) motivation plays a crucial role.

Individual and Societal risk are used as risk criteria. Acceptability criteria are set for both. The HSE will provide recommendations with regard to a planned (urban or industrial) development: ‘advise against’ or ‘don’t advise against’.

3.4 GERMANY

The German approach based on the Seveso directive is a fully deterministic one. This follows from a constitutional requirement that, in principle, activities that can lead to accidents with life- or health threatening effects shall never be tolerated. This principle was further acknowledged in procedures around the Kalkar debate in the late 1970s. Whatever measures can be taken to reduce the probability of occurrence of such accidents shall be applied. The risk analysis thus forms the basis for evaluating whether state-of-the-art technologies are applied. Basis is a hazard identification process using structured techniques like HAZOP (Appendix A), FMEA (Appendix A) and Checklists, as well as accident history and expert opinions.

Germany applies generic safety distances between potentially hazardous installations and vulnerable (populated) areas. The values of the safety distances have mostly been derived through expert judgement and based on historical data and experience with similar installations / situations. Eventually, for the remaining hazards the possible consequence areas are assessed. The outcome of the consequence assessment is a consequence distance for (a limited number of) foreseeable accident scenarios. Quantification of damage areas is practically limited to the purpose of LUP. Regarding Critical Infrastructure (CI), the topic of the protection of CIs has been firstly seriously introduced in the German law in 2009: (BMJ, 2009a) is the act for civil protection and protection against catastrophes. The national strategy for the protection of CIs in Germany has been issued in 2009, (BMJ, 2009b). CIs are treated in terms of their physical planning by the guidelines (BMJ, 2009c). The interconnected responsibilities of the national government, regional governments and public acceptance are said to be important since 80% of a CI is owned by private disposers. It is declared that Germany Federal Government has to assist German Federal Lands. (BMJ, 2009b) defines three important pillars: Discover risks in the forefront of an incident, reduce negative consequences with appropriate risk management programmes and constantly revise existing structures.

Fig. 3-2 (taken from (BKK, 2011)) shows the theoretical application of risk assessment and risk treatment in Germany. The issues are the declaration of risks, the preparation of measures to deal with risks, the acceptance of possible catastrophic events followed by reactions to deal with outcomes and finally the management and rebuilding of (critical) infrastructures.

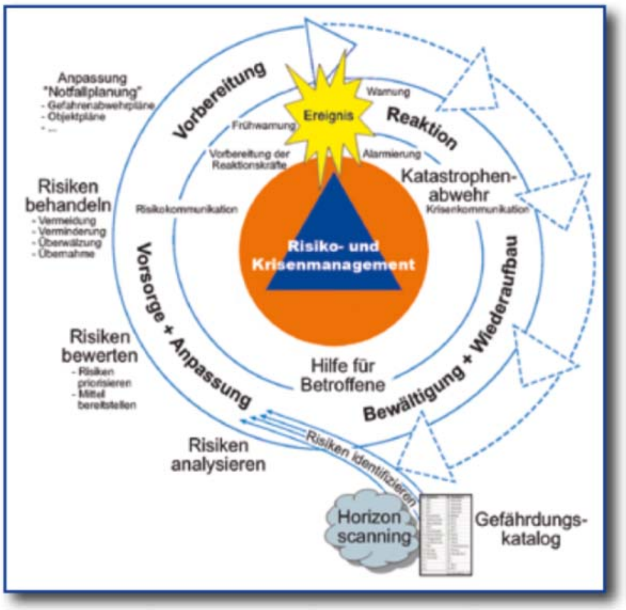

Fig. 3-2 Risk assessment and management of catastrophes in terms of public protection, Germany

<u>German guideline for companies and governments: </u>(BKK, 2011a)

The application of risk analysis in Germany is introduced, in which the decision for one of the three in the following proposed approaches is made based on the efforts needed. Risk analysis is applied to define risk causes and links between individual risk scenarios.

- The "qualitative approach" can be applied in order to derive defined "critical criteria" analysis. Risk assessment then defines coarse descriptions of theoretical events. Comparisons in numbers are not intended in the qualitative assessment. Based on the evaluations, the risk sources in companies and governments are evaluated. Criteria for decisions are life and health, affected volume e.g. of products, time of occurrence, dependency on different contracts, economical damages and environmental damages.
- The "semi quantitative approach" to apply risk assessment is proposed. In this case, numbers are assigned to theoretical risk values in order to achieve comparability.
- The introduced "quantitative approach" to risk analysis is based on simulation models. Occurrence probabilities are assessed.

The "semi quantitative approach" and the "qualitative approach" are said to create a good company-internal comparability. Measures should be implemented for the sub processes, which emanate the highest risks.

Germany has issued a series of documents under the context "Bevoelkerungsschutz" ("Civil protection"), from which three important ones are: (BKK, 2010) deals with the protection of CIs, (BKK, 2011) deals with risk management and (BKK, 2012) proposes measures for communication in terms of risk management.

(BKK, 2009 - 2012) manage the project KritisKAT (BKK, 2009 - 2012), in which CIs are categorized in terms of their influence in case of a failure. (BMI, 2009 - 2010) has been an national exercise to enforce proper crisis management.

3.5 SWITZERLAND

Although Switzerland is not an EU Member State, the Swiss Agency for the Environment, Forest and Landscape (SAEFL) has reflected the Seveso II Directive in most of the regulations with regard to major hazard industries: the Ordinance on Protection against Major Accidents (OMA) (Gmueder, et al., 2002). This Ordinance reflects well-established procedures in risk control, in particular those used in The Netherlands in the context of the environment control policy, e.g. the quantitative risk approach. At the same time, the OMA requires implementation of the state-of-the-art technology in agreement with the German practice.

The following definitions for ‘hazard potential’ and ‘risk’ are given in OMA:

- ‘Hazard potential’ means the sum of all the consequences, substances, products, special wastes, micro-organisms or dangerous goods could have as a result of their quantity and properties.
- ‘Risk’ shall be determined by the extent of the possible damage to the population or the environment, caused by major accidents and by the probability of the latter occurring.

Assessment of hazard potential and risks is done in a two steps procedure:

1. Submission of a Summary Report by the facility owner, comprising:

- A list of hazardous chemicals and their quantities, and whether threshold quantities of OMA are exceeded;
- Detailed description of existing safety measures;
- Estimation of possible damage to the public or the environment in case of accidental LOC.

2. Submission of a quantitative risk assessment (QRA), in case the Summary Report shows that major accidents and serious damage must be expected.

The need for consistency in the application of the OMA and in the conduct of QRAs was recognised in an early stage. Therefore, the SAEFL published a series of guidance documents for risk analysts and reviewers:

- Handbooks, with the status of (prescriptive) guidelines, explaining the risk analysis process and the damage and risk evaluation;
- Manuals, which are specific for the hazard and risk assessment specific to a particular type of installation. It includes typical accident scenarios and prototypes for fault-tree / event-tree analysis;
- Case studies for fictitious facilities, containing models and data for similar types of installations.

Fault/Event-tree assessment is an essential element in QRAs in Switzerland. In addition to this top-down approach, also a bottom-up approach of causes is encouraged, for instance through HAZOP, FMEA and similar.

The objective of risk assessment is twofold: (i) to control the risk level of the major hazardous facilities, and (ii) to inform the public.

Considerable effort has been put into making the hazard and risk assessment simple and accessible to the facility owners. Still, it is expected that both risk analysts and reviewers be knowledgeable in the principles of QRA. Usually, the owners of the facility contract a specialised engineering firm to perform the QRA. There are no requirements for the risk analyst to formally document his or her competence.

The consequence models are supported by LOC events defined in the Manuals.

Typically, in Switzerland the (presentation of) risk assessment covers more than only danger to life among the public. Damage indicators (‘Disaster Values’) have been defined in the OMA, comprising:

- Populations: fatalities, injuries [number];
- Natural resources: surface water [m^3 or km^2], ground water [m^3] and soil [km^2];
- Property [CHF].

For each ‘hazard recipient’ the Disaster Values are expressed on a uniform scale of three categories: “Accident”, “Major Accident” and “Catastrophe”.

In the societal risk curve, these Disaster Values are presented against the expected frequency of occurrence. The acceptability matrix of the curve presents four domains, namely:

- No serious damage, i.e. no group risk: < 10 fatalities, or < 100 injures;
- Acceptable: 10 fatalities at $f < 10^{-7}$/year, with N^2 rule for risk aversion;
- Unacceptable: 10 fatalities at $f > 10^{-5}$/year, with N^2 rule for risk aversion;
- Transition, the area between “Acceptable” and “Unacceptable”.

The guidance for the protection of CIs in Switzerland defines ten sectors (governments, energy, waste disposal, finance, health, industry, information and communication, food, public security, traffic), which are divided in 28 subsectors (e.g. sector "Energy" has the subsector "Natural gas supply"). For individual CI sites ("Individual objects") measures have advanced. The superregional work had been enforced before 2012 (BABS, 2012). The approach is risk based: In principal every possible hazard is considered. One constraint is the commensurability: The implementation of measures has to be in an acceptable ratio compared to the costs. Measures have to be taken by stakeholders but need to be enhanced with cooperation with public governments. The process in Switzerland is on-going: The final phase is scheduled for 2015.

The "Funktionswerteinheit" is a functional value, defines the losses as a function caused by the loss of an individual objects operation.

The "Gefahrenpotential" is the potential of danger, which is emitted from a dangerous substance. Goods of this type are covered with the cited regulation (BAFU, 2013).

- Quantitative efforts are defined by comparing the standard production of a product compared to a minimum critical value – these results are compared to population equivalents, in order to make effects measureable. These equivalents are defined by Swiss experts.
- Qualitative efforts are compared with function values. The ratio of a blackout is compared to the original capacity. An individual element may cause an extensive loss of the overall system's capacity. The range of values to compare is between zero and one. A value of zero defines zero dependency of the entire system on an individual failure. The value one defines a system failure and thus has maximum priority. In the "Serial system definition", in the case of a failure, a failure of an individual object results in a reduction of all connected function values.

(BABS, 2010) discusses infrastructures of the type energy, traffic and communication, because of their strong connection. A primary objective of the project has been to increase communication of the different parties. The "Bundesamt fuer Bevoelkerungsschutz (BABS)" ("Federal Office for Civil Protection") established a programme for the protection of CIs in Switzerland. Dependencies are discussed, e.g. important for finding the weakest point among connected facilities. International communication, long-term planning and various concepts are under investigation.

The programme "Katarisk" (Katarisk, 2003) has been introduced by the Federal Office of Civil Protection to enforce risk assessment from a public point of view. Main ideas are introduced with the questions "What can happen?", "What is acceptable?", "What can be done?" and "What measures can be implemented?". These elementary questions, combined with graphical illustrations to assess risks from different events and explanatory descriptions, allow public accessible risk management.

The principles of the cantonal guide to evaluate civil threats in Switzerland and how to deal with the three previously introduced questions have been introduced with "Kataplan" in 2008. (BABS, 2012) is cited because it is a revised report.

3.6 AUSTRIA

(BMVIT, 2008) is the Austrian adaption and realisation of the (EC, 2006), which has the purpose "to ensure Austria's economic place of significance". (BMVIT, 2013) is a national safety research program, which deals with CIs in Austria. It is based on the principles proposed by the European Programme for Critical Infrastructure Protection.

(BMI, 2000) is a publicly available document dealing with hazards of CIs. How to deal with a possible hazard, how a possible hazard could occur and which consequences could result are the main topics of the document. The report is meant to increase public awareness on risks related to CIs. (BMI, 2013) has been recently issued. It is an electronic guide for private stakeholders to evaluate their own business and CI.

(Bauer, 2000) assists with questions regarding Austrian risk maps for alpine torrents and in a similar way avalanche maps. The website (BMLFUW) is a publicly accessible hazard map, which is meant to assist with the assessment of risks, to which selected regions in Austria are exposed. Hazards can be estimated for different events, thus increasing public awareness. The topic of flood risks is very up-to-date in Austria, because of their occurrence in the past years.

3.7 FRANCE

Initially the French regulations followed a deterministic approach. The requirements comprised the presentation of consequence distances for a number of scenarios that are to be determined by the plant owner. Some guidelines on modelling were available, but no strict requirements were set.

This has changed after the Toulouse tragedy in 2001 where a series of explosions of ammonium nitrate caused about twenty fatalities, many injuries and extensive property damage. Since then, the French government has issued several new and stricter regulations, especially for land-use planning ((MLPE, 2004), (MLEP), (MESD1, 2003), (MESD, 2003), (MESD2, 2003), (MESD, 2004)). Several guidelines are now available giving the types of loss of containment, analytical equations for assessing consequence distances for typical events, and prescription of the presentation of the results. End points of calculations are clearly set, e.g. levels of heat radiation or toxic exposure. Also the procedures followed to select scenarios to be included in the safety report, have recently been made clearer and more uniform. This includes mandatory consultation of accident databases, structured identification methods (e.g. HAZOP) and selection of relevant scenarios with the help of a risk matrix. A quantified frequency assessment is (will be) required to give evidence that the likelihood of certain scenarios is sufficiently low (e.g. $< 10^{-6}$/year) in order to rule them out from the external effects calculations. A (revised) set of requirements is expected to be issued early 2005.

The French government has assigned a limited number of independent experts (‘Tiers Experts’) that will assist in the evaluation of safety reports submitted by the plant owners. These experts regularly meet to exchange views and experiences, which results in more uniformity and increasing understanding about the issues of risk analysis. Their conclusions will probably be reflected in the future guidelines. It appears obvious that the current practice in France is a very dynamic one, in which the probabilistic phenomena will receive an increasing interest.

3.8 SPAIN

In Spain, the formal national requirements with regard to Seveso-II are described in the ‘Directriz Basica’. The approach with regard to risk analysis is basically a deterministic one. For a number of accident scenarios, the consequence areas (distances) have to be assessed and mapped for a set of prescribed effect values like heat radiation and explosion overpressure. Not only areas for fatalities are required, but also areas with potential injuries. The values are directly related to emergency response levels. Except for Catalonia, policy for using risk analysis for LIC or LUP appears hardly to exist in Spain.

Regional differences are observed in Spain. In the province Catalonia for instance, the regional authorities often require a probabilistic assessment to be provided in addition to the national requirements. Use of the Dutch tools and CPR-models is encouraged.

3.9 FINLAND

In Finland the deterministic risk assessment approach is applied in the industry related to dangerous chemicals. The Finnish Chemicals Legislation doesn't specify the methods that should be used in identifying hazards or evaluating risks. The competent authority (TUKES) requires a description and the control of possible hazards at the plant, as well as measures for protection and intervention in the limitation of the consequences of accidents. At the higher tier plants the use of systematic methods is required by the competent authority. Consequences of major accidents are usually evaluated by using the models of accidental releases.

The results of risk analysis are also used for emergency response planning, by the local rescue services.

Risks are often evaluated in a coarse way by using a semi quantitative assessment, e.g. a risk matrix, in which an evaluation is based on simple numerical values. In this method evaluated consequences are multiplied by an evaluated likelihood of an incidence. The result describes a severity of a risk. This type of assessment is a prevailing practice in the higher tier plants, but not a mandatory one for submission in a safety report.

3.10 GREECE

In Greece, the requirements for safety reports are limited to common interpretations of the Seveso II text, and thus neither quantitative risk analysis nor environmental risk studies are required.

As far as safety report supporting instruments are concerned, Greek practice is poor in instruments and guidance (Steen, et al., 2004). The single exception is a zoning system with certain consequence criteria that have been widely accepted since they have been proposed by the Ministry of Environment for the external emergency plan of industrial areas. The zoning system comprises three levels of consequences that are based on damage criteria such as TLVs for toxic substances and certain thermal doses and overpressures. This system is widely accepted but not formally adopted. Safety reports have been developed using these criteria to identify the extent of possible damage in the surroundings of the establishments.

In Greece, no formal risk criteria or risk assessment methods exist. Some safety reports were developed with the support of certain risk criteria used in industrial practices of other EU member states. Used information comprises (SHAPE-RISK, 2004):

- For hazard identification and/or LOC definition: International databases of failure records, Reports from equipment reviews, Checklists, Literature and international guidelines, Reports on ‘lessons learnt’ and on ‘near miss analysis’, LNG Standards from NFPA and EN.

- For identification of failure causes: HAZOP, Accident analysis, What-If, Fault-tree & Event-tree, International guidelines.
- For consequence assessment: Gas / toxic cloud dispersion model in PHAST-Pro (refineries), Scenarios for release and ignition of LNG: dispersion with DEGADIS.
- For QRA: QRA is not required.

Although QRA is not required, the following information / data sources are mentioned for risk assessment:

- Seveso I: individual risk and societal risk; Seveso-II: Dose zones;
- Dose zones defined by the Ministry of Environment;
- Meteorological data;
- Substance characteristics;
- Quantification of external effects based on distances of toxicity and radiation levels;
- However, guidance on quantitative data is not given.

3.11 SWEDEN

From Sweden, the information is based on documentation from the Rescue Service Agency. Decision support is based on a risk matrix approach, in which semi-quantitative classification of consequence severity and incident likelihood are presented. Consequences are expressed in human life, damage to the environment and financial loss of property.

The results are used to prioritise risks in municipalities, to evaluate possibilities for accident prevention and to plan for emergencies.

3.12 UNITED STATES OF AMERICA

In the USA, the responsibility of risk assessment requirements lays with the US-EPA. They have developed the policy of Risk Management Plan (RMP) which requires major hazard industries to submit an RMP document (US-EPA, 1999). This document shall provide information primarily required for emergency response planning. Basically, the approach is a deterministic one.

At least two scenarios have to be evaluated and to be quantified in terms of consequence distances for each relevant installation:

- The first one is a major or catastrophic incident, usually defined as the loss of containment of an installation within 10 minutes, at constant rate;
- The second one is a scenario that is considered to be a ‘more likely serious incident’, to be defined by the operator.

For both, the consequences have to be assessed and mapped. The results are communicated to the local authorities and the public, and form the basis for the civil protection agencies and public forums.

US-EPA provides guidance documents and consequence assessment software to support a consistent and uniform application of the matter. No evidence has been found that risk analysis results are used for environmental permit procedures. The results do play a role in land-use planning, though no formal risk based acceptance criteria are used.

4 CI-A1: Oil refinery and petrochemical plant, CI-B3: Port infrastructure

More than 130 refinery establishments are in operation in Europe taking into account Candidate Countries and also Switzerland and Norway (see (JRC, 2006)). Nine major accidents have been reported to the European Commission since 2000. Beside their economic importance, petrochemical plants processing high volume flammable hydrocarbons could induce major environmental and economic hazards. CIs producing petrochemical substances are thus highly important for the European economy and subjected to cross-border regulations. The critical coupling of extending the operation time of CIs beyond the designed life cycle time, and identifying the crucial point when an incident could occur, has become a major challenge.

The risks from port infrastructures are in general mainly related to the transport, storage and processing of hydrocarbons.

4.1 EUROPEAN STANDARDS

In chapter 2, European guidelines, recommendations and laws on how to deal with possible hazards of CIs, e.g. dealing with chemical substances, have been introduced. The Seveso III (EC, 2012) regulation entered into law in August 2012 and is the latest European Directive regulating the treatment of chemical substances in the European Union. Member States have to transpose and implement the Directive by 1st June 2015, which is also the date when the new chemicals classification legislation becomes fully applicable in Europe. It now applies to around 10 000 industrial establishments, mainly for industrial sites, which are used for the storage of chemicals and also the 130 introduced petrochemicals. In case of the use of chemical substances exceeding certain thresholds, the public could be affected by accidents, and thus must be informed. Safety reports, safety management and internal emergency plans are compulsory. Additionally, European Member States have to ensure the availability of emergency plans for surrounding areas. It is stated in (EC, 2012) that with the introduction of the regulation (EC, 1982), the probabilities and consequences of chemical accidents have decreased significantly, even though the level of occurrence of such incidents has been relatively constant. Risks related to cascading effects should be reduced by the cooperation of stakeholders of interconnected CIs.

Beside European Standards, (M. D. Christour, 2006) has already been issued as an extension of the Seveso II regulations. It gives detailed information about Land Use Planning's in areas close to a chemical industry and thus the document is intended to give guidance for risk assessment.

(Krausmann, et al., 2011) discuss industrial accidents (related to CI) triggered by hazards, for amongst others, oil- and gas-storage-systems and -refineries. Natural disasters caused by technological hazards are denominated as "NaTech" accidents. In relation to national standards, in the cited report, the demand for emergency plans and early warning systems is mentioned.

(SYNER-G, 2012) developed a framework for the assessment of physical and socio-economic seismic vulnerability at the urban/regional level and could be considered for the assessment of the port infrastructure, Thessaloniki, Greece. The built environment is modelled according to a detailed taxonomy into its component systems, grouped into the following categories: buildings, transportation and utility networks, and critical facilities. The framework discusses all aspects in a chain, from regional hazard to fragility assessment of components to the socioeconomic impacts of an earthquake, accounting for all relevant uncertainties within an efficient quantitative simulation scheme, and modelling interactions between the multiple component systems in the taxonomy.

4.2 NATIONAL STANDARDS (SELECTED COUNTRIES)

Northern **Italy** has a high concentration of hazardous plants. In comparison, in terms of risk assessment, CIs in Southern Italy are more critical. This is due to the fact that many sites of these CIs have been in operation for approximately 50 years and thus require more control. The Milazzo oil refinery and petrochemical plant is located in Southern Italy. Thus it fulfils these criteria and requires intensive risk assessment.

Italy introduced the Seveso II directive according to the European Law with the Decree (IG, 2005). Risks are considered as functions of the quantities of hazardous substances present at sites. The ISPESL is the Italian technical-scientific body of the Ministry of Health for all aspects of safety and hazard and risk assessment. Under the guidelines of federal institutions, territorial agencies operate on national Italian territory. The DIPIA Department provides the enforced support for CI stakeholders for the implementation of the Seveso II directive (EC, 1996). Specific features are included in the Seveso II guidelines in Italy: The Port Safety Report gives a summary about all major hazardous activities. It defines the carrier of a CI to be a possible source of hazard. Port authorities have to define port emergency plans. In accordance with the Seveso II guidelines, Integrated Area Safety Reports are used to coordinate risk assessment in areas, in which CI is situated. This should be done with the idea to reduce the risks of Domino Effects and cascading hazards. Italian control activities are comparable to other European Countries.

In **Germany**, (BMJ, 2013) has already been introduced in this summary of state-of-the-art national codes and guidelines. It is the latest version of the German principal ordinance, which regulates exceptional industrial hazards. In particular, CIs, which deal with dangerous substances (A list of dangerous substances can be found in (BMJ, 2013)) are regulated in the guidelines. Among these substances, any substances of mineral oil products are specified. Thus, this guideline is fundamental for any decision making related to the CI-A1.

The term "danger" specifies negative influences in three grades, thus their effect on a major group of humans, particular danger for some humans and the possible general effect on animals and environment. The demands to prevent and limit consequences, which are caused by hazardous incidents, are highlighted. Any maintenance work and thus revising work on CIs has to be state-of-the-art. The often mentioned demand for emergency plans and concepts to avoid hazardous events and the appertained communication with federal governments is assigned to risk management and an important issue of the (BMJ, 2013). Any proposed measures have to be revised at least every five years. The German ordinance furthermore states that in cases of possible cross boarder effects, affected governments and / or institutions have to be informed. Special treatments by governments are specified, if possibilities of domino effects concerning different departments of CIs, are apparent. Risk assessment is mentioned specifically in the guidelines to assess possible hazardous scenarios and their probability of appearance. Geographical consequence scenarios related to extreme events have to be documented in accordance with the German guidelines.

(BAFU, 2013) is the Swiss ordinance dealing with hazardous events influencing CIs in **Switzerland**. The intention is to protect human population and environment. Transport facilities (railway constructions, trough streets and the Rhein river in Switzerland), which are used for the transportation of dangerous substances are regulated in the Swiss ordinance. Typically, CIs like the CI-A1 are depending on such transport infrastructure. Certain types of pipelines are subjected to the "Rohrleitungsverordnung" (BAFU, 2013), the "Pipline Act", see chapter 7. The term "risk" is mentioned early in the guidelines as the consequences of a hazardous event in combination with its probability.

The definition of measures such as hazard plans and emergency plans are compulsory. Thus, risks are categorized and evaluated. Risk assessment has to be conducted by stakeholders with a short risk analysis report, which is examined by the enforcement agency. Individual responsibility should lead to failure prevention. Cantonal governments can influence measures already prior to the erection of CIs by defining admission maps. Registration offices are defined, which enforce risk management and the communication with federal governments and thus control the individual responsibilities of CI stakeholders. The Swiss government is responsible for the treatment of cross boarder communication.

Risk assessment is proposed with an assigned appendix. Risk management is divided into three categories: "reduced hazard potential", "avoidance of hazardous incidents" and "reduction of hazardous impacts".

According to (BAFU, 2013), even if risks exist in acceptable thresholds, stakeholders have to reduce these risks if necessary actions can be accepted in economic terms. The decision is based on estimates of the probability of occurrence and / or if risks are acceptable. Guidelines and recommendations for enforcement authorities on the evaluation of CIs are proposed in (BAFU, 2001). Clearly formulated recommendations, based on experience of previously issued editions of these guidelines are used to define diagrams, in which probabilities of failure are presented as functions of their consequences. Risk assessment is conducted, based on these cumulative curves.

(BAFU, 1996) is an exemplary and detailed risk assessment examination for a liquid gas storage tank complex.

(BAFU, 2008) is a detailed extension to the guidelines (BAFU, 2013). E.g. the proposed risk assessment measures are detailed: Based on the short reports of stakeholders, possible hazards are examined. The Swiss controlling institution decides whether further actions have to be considered or not. Risk analysis has to be applied for connected individual CI sites if these are located in a combined complex.

(BAFU, 1996) has been introduced to identify facilities in Switzerland, which have the potential of hazardous events. The specified industrial sites are distinguished according to

(BAFU, 2013) into groups of facilities, which demand risk assessment and CI, which do not demand risk assessment, see Fig. 4-1. This résumé of facilities in Switzerland is updated every four years.

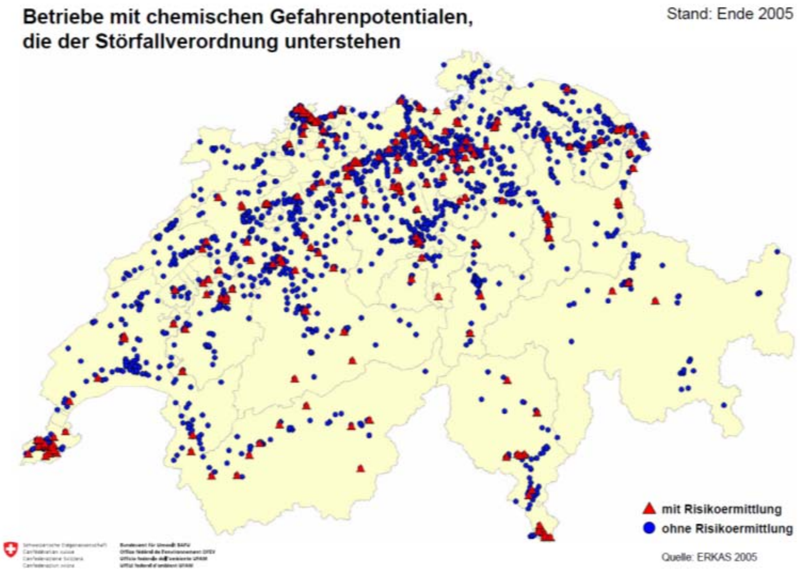

Fig. 4-1 Facilities in Switzerland with potential of chemical hazards

The **Austrian** guidelines "Industrieunfallverordnung (IUV)", (BKA, 2013), "Industrial Accident Guidelines" defines the industrial treatment of dangers related to hazardous accidents in industrial plants and waste treatment facilities. It is Austria’s national adaption of the Seveso II guidelines (EC, 1996). Cross boarder accidents are furthermore covered with this guideline. Clearly, the examined CI-A1 would be under supervision of this guideline in Austria. Key points are safety concepts, information systems in case of an accident and safety reports. The inclusion of consequences on the environment, similarly, the definition of possible hazard sources is demanded. Public announcements in any case of an important industrial facility are compulsory.

5 CI-C1: Industrial district

Emilia-Romagna is an administrative Region in Northern Italy. The industrial district located in the Emilia region is chosen as one of six CI sites because of its economic importance. Because the district has been hit by multiple earthquakes in 2012 and major damage occurred at the seismically unsafe buildings, the chapter focuses on how seismic actions on structures in Europe are defined.

The wide spread damage led to major consequences in the entire region. Although the shocks were not exceptional, they caused huge damage. The earthquake series led to major economic consequences, because the majority of the entire region's industry collapsed. The losses were estimated to be more than 15 billion Euros.

5.1 EUROPEAN STANDARDS

(EN1991, 2014), the "Eurocode 8", covers earthquake resistant design of structures. In National Appendices, regional seismic hazard levels are identified. A comparison of different European national building codes is made in (JRC, 2008).

The European Seismic Hazard Map (SHARE, 2013) has been completed as a contribution to harmonize available National Appendices.

5.2 NATIONAL STANDARDS (SELECTED COUNTRIES)

In **Italy**, the addressed industrial district in the Emilia region has not been identified to be seismically sensitive prior to 2003, see Fig. 5-1. This expresses that the buildings in the district were not designed to withstand earthquake shaking. Thus, the huge damage occurred even though the earthquakes were not extremely strong. In Fig. 5-1 the industrial district is indicated with a star symbol. The introduced seismic zones after 2003 are regulated in the Italian National Appendix of Eurocode, (EN1991, 2014).

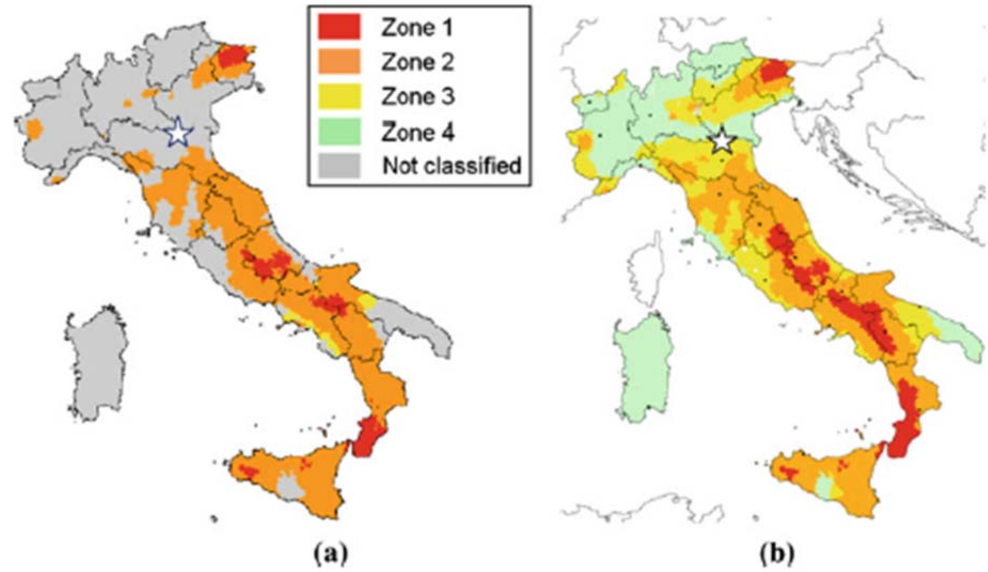

Fig. 5-1 Seismic zones, Italy, before 2003 and after 2003

Switzerland uses its building code (SIA, 2003) to identify national seismic zones.

(SEISMO, 2014) is the website of the Swiss Seismological Service "Schweizerischer Erdbebendienst". Fig. 5-2 is provided by this service. It combines the "seismic hazard" with "local soil properties", "exposed values" and "vulnerabilities" (subfigures 1-4). From these values, risks are assessed. The right subfigure in Fig. 5-2 (taken from (SEISMO, 2014)) presents the results in a map plot. The highest seismic hazards (left subfigure) are identified in the south-west regions of Switzerland. The resulting risk map (right subfigure) shows high risks in densely populated regions, which need not be exposed to highest seismic hazards.

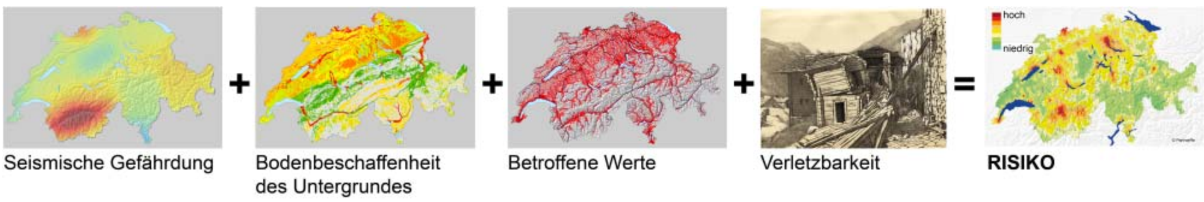

Fig. 5-2 Risk assessment, illustration

6 CI-A2: Large dams

Large dams have been built mainly with the purpose of generation of electrical power. The massive structures are also designated for the absorption of flood events. Because of their often high filling level and size, the structures have a great potential of causing large damages. Natural hazards such as earthquakes, landslides and floods induce risks of failure. An open discussion about dam safety is essential to create a positive opinion in public acceptance, see (Garbe, 2007). Risk assessment is typically considered in terms of analysing flood waves caused by dam breaks and thus considering extreme events consequences and impacts on society. Emergency plans and supporting alarm systems are typical measures to initiate public discussion about possible risks of dam hazards. These efforts encourage society to deal and discuss with theoretical risks, which could emanate from large dams.

6.1 EUROPEAN STANDARDS

(EC, 2008a) is the European guideline to assess and evaluate risks of ECI. Infrastructures, which are used for power generation (beside nuclear power stations) are covered by these guidelines, and thus, large dams have to be evaluated according to this guideline.

The International Commission on Large Dams (ICOLD) is a worldwide organization basically formed with the intention to increase the safety of large dams. (ICOLD, 2005) has been issued to deal with risk management of dam sites. (Bowles, et al., 2007) is a public available recapitulation of the bulletin, summarizing the main issues on how to treat hazards. The latter are classified in a hazard classification system. The majority of the European countries are involved in the ICOLD (e.g. Austria, France, Germany and Switzerland).

6.2 NATIONAL STANDARDS (SELECTED COUNTRIES)

In (Garbe, 2007), 21 countries and their national standards are examined and compared on how remaining risks of large dams are assessed. Important issues are the analysis of dam breaks and resulting flood waves. Emergency plans and alarming systems are designed based on these models. Regulations and treatment of disclosed risks are said to be suspected to a general and broad discussion in most of the countries. A survey consisting of four different criteria to assess and treat the remaining risks is proposed in Table 6-1, c.f. (Garbe, 2007). Apparently the majority of the examined EU countries have an obligatory concept of risk analysis and treatment.

Table 6-1 Criteria to assess and deal with disclosed risks of dam hazards

National code	Risk analysis and -treatment	Flood wave and break of a dam	Emergency plans and -concepts	Alarm systems
France	obligatory	obligatory	obligatory	obligatory
Italy	obligatory	obligatory	obligatory	obligatory
Germany	obligatory	obligatory	obligatory	obligatory
Norway	obligatory	obligatory	obligatory	supplemental
Austria	supplemental	supplemental	supplemental	no declaration
Portugal	obligatory	supplemental	obligatory	supplemental
Switzerland	obligatory	obligatory	obligatory	obligatory
Spain	obligatory	obligatory	obligatory	supplemental
Czech Republic	obligatory	no declaration	no declaration	no declaration

In (BMLFUW, 2009), a table summarizing national approaches to deal with previously introduced natural impacts is shown, (pages 43-44). Risk assessment and management is not directly discussed. Spain, Sweden and Great Britain classify dams in terms of damage potential, which is some kind of risk assessment.

The DIN 19700:2004 (DIN, 2004) **Germany**'s national standard regulating water-retaining structures. The most recent edition is composed of six chapters and has been introduced in 2004. Chapter 11 deals with structural reliability of large dams. The safety concept combines uncertainties of the external inputs and of the structural resistance. In the new version (2004), partial risks are considered. These have to be accepted. Analysis of potential damages as a result of certain failure scenarios and especially of risk acceptance values are not introduced. Specifications regarding the method of risk assessments are not defined. The standard forces the discussion of disclosed risks, thus their effects and treatments, which results in a risk based assessment.

A classification of individual dam sites is proposed. It is mainly based on the potential risks caused by any type of hazard by this dam. This classification is based on risk assessments, which can be combined with additional geometrical assessments. The DIN 19700:2004 requires risk assessment and reducing the residual risks in specified design cases: floods and earthquakes. Likewise the consideration of risks induced by earthquakes, the combination of bearing structure and foundation has to resist as a combined structural system the design input of higher probability of occurrence without any damage, whereas in case of an more unlikely extreme event, the structure has to resist the natural input, but may experience structural damages. The risks of material characteristics dispersions and failure of special structural installations are addressed. Monitoring and thus maintenance are defined to be important for a long-term inspection. A number of additional rules (e.g. the demand on planners with competence, emergency preparedness) are used to cover so-called "other risks" and reduce tolerance levels. Important literature discussing risk management in national German dam guidelines can be found in (Sieber, 2000) and (Sieber, 2005).

In **Switzerland**, the "Stauanlagengesetz" ("Water Retaining Facilities Act") (BFE, 2013b) and the "Stauanlagenverordnung" ("Water Retaining Facilities Decree") (BFE, 2013a) are the law and decree regulating large dams under the guidance of the Swiss Federal Office of Energy (SFOE). An important distinction is made by selecting whether single dam sites are under supervision of (BFE, 2013a) using criteria defined in (BWG, 2003). In the latter document, the consequences of a potential failure are discussed. However, the probabilities of appearance of such an extreme event are not evaluated. The question if hazardous exposures influencing a single site have to be discussed, is introduced by (BWG, 2003), in which the terms "besondere Gefahr" ("particular hazard") is related to the term "besonderes Gefaehrdungspotential" ("particular potential of hazard"). This assignment appears to be a subsequent extension to enforce the discussion of risk assessment.

Because of the guidelines of "Katarisk", the federal Swiss government has to deal with catastrophic hazards related to large dams.

Compared to STREST, natural hazards are defined in the Swiss Standards as any change of performance, mass movements in terms of slides, floods, earthquakes and different inputs such as explosions. These extreme events are highly unlikely but physically possible in their appearance.

The safety concept and thus risks are assessed with a concept of three pillars: planning and design, monitoring and maintenance while in operation. Emergency plans in case of an extreme event are introduced as a third pillar. These three pillars are used to treat uncontrollable risks.

Additionally, a number of different documents are proposed by the SFOE to conduct risk management, which deal with earthquakes excitations, floods, monitoring and maintenance. Risk assessment is proposed by detailed remarks on the computation e.g. of hazards such as flood waves.

In 2013 and 2014, a revision of the existing standards on the assessment of unexpected hazards, is intended. Table 6-1 documents the approach to address the safety of large dams in **Austria**. Design standards treat risks related to large dams considerably more “generously” than the majority of other analysed countries. In (STK, 2010), a similar statement in terms of earthquake incidents is issued. The guidelines do not necessarily represent the state-of-the-art. Risk assessment is under supervision of responsible experts opinion. The law regulating water treatment ("Oesterreichisches Wasserrechtsgesetz") includes large dams, see (BMLFUW, 1959). A fundamental principle mentioned in the guidelines is: Any measure influencing dam structures needs to be in accordance with the current state-of-the-art.

Monitoring is one key point for dam safety mentioned in the guidelines for structural safety in 1996, see (BMLFUW, 1996). A possible earthquake hazard is mentioned in the guideline for structural stability as "maximum conceivable earthquake event", which implies that there has not been a detailed discussion about hazards and extreme events in the guidelines, (BMLFUW, 1996).

In (BMLFUW, 2001), earthquake loadings are discussed. Dams need to be designed to be safe in case of an improbable and rare extreme event. Again, this principle does not imply any type of risk assessment or risk management. It is mentioned that structures of this type are not subjected to strict safety rules and guidelines, see Table 6-1.

The guidelines of Austria assert an elementary potential of danger, to which humans are exposed. Only dam sites, which have a runoff in existing river runways are considered simplified as less affected by flood hazards.

In (Melbinger), twelve elementary assumptions on safety treatment of dams in Austria are proposed. Emergency plans, in terms of risk management, have to be prepared "in case of an extreme event", see (Melbinger). Safety commissioners are responsible for their assigned dam. Risk assessment and methods are not proposed.

In (STK, 2010), the National Standards of Austria, France, Germany, Italy and Switzerland are compared. However, LPHC events are not discussed. It is stated that France has a strict but national standard.

7 CI-B1: Major hydrocarbon pipelines, CI-B2: Gas storage and distribution network

Approximately 85 per cent of natural gas used in the European Union is transported via pipelines. The majority of gas is imported to the EU-27 countries from outside the EU-27. The demand and dependency on gas will increase in the future. Climate objectives influence gas pipelines systems, because e.g. wind energy minima could increase gas deliveries in peak times. Already now very high capacity usages at some interconnections appear (cf. (EP, 2009)).

The delivery of oil products is more flexible, (EP, 2009), thus only about 20 per cent of oil products are transported with pipelines. The connection of Eastern and Western Europe is weak. Additionally, Eastern Europe is vulnerable to the supply of Russian hydrocarbon products.

Typically, pipelines are built over long distances and extended with external infrastructures such as pump stations to provide sufficient reliability and transmission. In the European Union, about 290 000 km "major accident pipelines" are in use, see (EC, 2011). $250*10^3$ km are high-pressure pipelines, additionally $1.7*10^6$ km low-pressure pipelines are in use. Oil pipelines mean the risk of environmental hazards, whereas gas pipelines mean direct risks for humans.

The development of oil- and gas pipelines via Turkey is a key issue to increase the quality of the European fossil energy supply. The investigated hydrocarbon pipelines (both for gas- and oil products) in Turkey, CI-B1, crosses different fault zones, which makes the pipeline vulnerable to seismic vibrations.

In relation to low-pressure pipelines, The Netherlands are considered in terms of CI-B2. The largest natural gas field in Europe is located in Groningen, Netherlands. It contains approximately 3000 billion m^3 natural gas. Approximately 100 other gas fields exist in The Netherlands. The distribution network is an interconnected system of CI. Up to 100 different buildings are located in service of the gas grid to guarantee its functionality. Risk assessment has already been applied. Masonry buildings and of single vertical pipe supports can hardly comply with Dutch design standards for earthquake safety. Other addressed hazards are floods, soil condition changes and collapsing of tall structures (wind turbines, electrical power lines), which could fall on the gas distribution network. The presence of risks is highly visible and declared.

7.1 EUROPEAN STANDARDS

On the European scope, (EC, 2011) provides the European Commission with information and analysis, from which improvements and benefits could be achieved if additional legislative actions on the safeties of onshore pipelines were defined. The Seveso guidelines do not cover pipelines, which are used to transport dangerous substances. Only Poland is said to have its own national guideline regulating pipelines. The relevance of this topic is made clear, because the (EC, 2011) concludes that a specified pipeline safety directive would be advantageous. (JRC, 1999) is mentioned as one of few finished discussions about pipeline safety. (UNECE, 2008) is a later non-mandatory guideline on pipeline safety.

(EC, 2011) states that the majority (about 90 per cent) of national European Governments define guidelines and recommendations dealing with oil- and gas-pipelines, see Table 7-1. (EC, 1985) is defined in (EC, 2011) to be a European Guideline, which regulates European pipelines. (EC, 1999) contains additional components used in the pipelines transmission system. (EC, 2006) can be used according to (EC, 2011) for pipelines, especially because of their cross-border relevance.

(EC, 2008a) is the European guideline, which also covers the storage, refineries and pipeline structures of hydrocarbon products. It is stated that these structures are critical in terms of the analysed CI. (EC, 2011) certifies different guides and recommendations, which are used for pipeline safety. The (ISO, 2004) is used to assess environmental issues related to pipelines. (OHSAS, 2007) specifies health and safety performance. (ISO, 2011) is commonly used for quality management. The Pipeline Integrity Management System (PIMS) is used to monitor pipelines, based on a strictly defined suite of activities.

One principal finding of (EC, 2011) is that Seveso II and III guidelines can hardly be applied, because it is difficult to assess the amount of emitted gas/oil in case of hazardous event. The amount (and type) of lost hydrocarbon product is the risk indicator in the Seveso guidelines.

The (BSi, 2011) is the British adaption of the according European Harmonised Standard, regulating petroleum and natural gas industries, respective pipeline transportation systems. (BSi, 2013) treats gas supply systems, with a pressure over 16 bar.

(SIPS, 1992) has been introduced to deal with cross-border industrial accidents, thus it is of importance for long-range Pipeline transport systems.

(ASME, 1999) is an American guideline, which regulates like the (ISO, 2010) offshore pipelines. It gives numerous recommendations and approaches on how to deal with and assess risks associated with offshore pipelines.

Table 7-1 Survey on risk management of European Countries

Country	Safety management systems	Risk assessment	External emergency plans	Land use planning	Information to the public	Third-party issues	Technical safety requirements
Belgium	++	++	++	++	+	+++	++
Czech Republic	+	0	+++	++	+	+++	++
Denmark	0	++	++	+	0	++	+++
Estonia	0	++	0	+	0	++	++
Finland	+++	++	++	++	+	++	+++
France	+++	++	+++	++	+	+++	++
Germany	++	++	+++	++	+	+++	+++
Ireland	+++	++	+++	0	+	+++	0
Italy	+	++	0	+	+	++	+++
Netherlands	++	++	+++	+	+	+++	Duty of care
Poland	+++	+	0	+	+	+	+++
Portugal	+++	++	0	+	+	+++	+++
Romania	+++	++	+++	+	+	0	++
Spain[6]	+ +	+ +	+	+ + +	+	+	+ +
Sweden	++	0	+	0	0	+	++
UK	+++	++	++	++	0	+	Duty of care
Croatia	++	+++	++	++	+	++	+++
Turkey	++	+++	+++	++	+	++	+++
Norway	++	+++	+++	++	+	++	+++

Legend: 0: no provision in place +: basic provision, ++ several provisions +++ many provisions
Source: Member State questionnaire replies

7.2 NATIONAL STANDARDS (SELECTED COUNTRIES)

The treatment of pipelines in **Turkey** is summarized in (EC, 2011). Turkey has introduced numerous recommendations and guidelines on how to deal with oil- and gas-pipelines. (SIPS, 2009) is a survey of different questions asked to Turkey (and to other countries), which deal with the national treatment of pipelines. The state body for the distribution lines is the Energy Market Regulatory Authority, which introduces numerous different regulations dealing with oil- and gas-products. In general, BOTAS and other Distribution Companies are responsible for the supervision of pipelines. Beside four important national laws (see (SIPS, 2009)), in which the pipelines associated projects have to be in accordance with, it is accepted in Turkey to follow international codes and guidelines, if these comply with national regulations. Thus, for all stages of pipelines, the conformity with international standards (ASME, ANSI) and also CE norms have to be ensured. Stakeholders manage their business in accordance with standards regarding quality management such as the (ISO, 2011) or the (OHSAS, 2007).

The Seveso Guidelines are the basis for the treatment of gas storage and transportation systems in **The Netherlands**. In accordance with the Seveso Guidelines, the Ministry of

Infrastructure and Environment is responsible for the overall coordination and transport of dangerous substances. Disaster response is organized by the Ministry of the Interior. The Ministry of Social Affairs and Employment is responsible for principal safety concerns.

Provinces and municipalities are responsible for large and small plants. In 2010, 434 Seveso CIs were listed in The Netherlands, from which 255 were defined as upper tier facilities.

Seveso III is implemented in two directives: (BRZO, 2013) is the Dutch Major Accidents (Risks) Decree. It uses a risk map, which shows "BRZO companies". BRZO companies are the high-risk companies in The Netherlands. It is the Dutch arrangement of the European Guidelines. Essentially and in accordance with the European Law, a safety report and quantity measures of hazardous substances need to be defined by companies. Typically in The Netherlands, flood risks are evaluated. Additionally, hazard risks caused e.g. by natural fires and earthquakes can be easily examined.

(BEVI, 2009) is a detailed guideline on how to assess risks. Risk evaluations need to be comparable and reproducible. Not only CI themselves are governed, but also the surrounding areas, which makes this standard additionally important for spatial planning.

In **Great Britain**, the Health and Safety Executive is a non-departmental public body, which is responsible for safety concern, e.g. for pipelines safety. (HSE, 1996) is the principal regulation, which is state-of-the-art because of revisions and extensions. Additional standards can be found in the context of "major hazard" pipelines. Generous reports and regulations are available for public interests. (HSE, 2012) shows how data to assess safety performance of pipelines in Great Britain: To increase data quality and quantity, detailed studies of near misses and even low consequence incidents are evaluated. These incidents and records are defined as "Safety performance indicators" and result in a bigger amount of accessible data, which can be used for risk management and assessment.

In **Switzerland**, a typical country representing the importance of pipelines in nations, which are not directly associated with the transportation of larger amounts of hydrocarbon products to supply the European Union, rises from large flammable substances are regulated in (BAFU, 2013), (BAFU, 1963) and (BAFU, 2007). Since its revision in April 2013, pipelines with a higher inner pressure than five bar are under supervision of this guideline. Risk assessment is done by dividing pipeline chapters into different colours (green, orange and red), from which red chapters have to be treated with more detail. The intention is to reduce the potential danger of hazards to remain in acceptable risk values. Every second loss of gas is said to be caused by externals, thus the Swiss Guidelines demand visual pipeline inspections at least every 14 days. Typically, an approach to reduce risks emanated by pipelines is to reduce pressure in the constructions.

8 Conclusions

This review and survey of European and national guidelines shows that the topic "risk" and "hazard" are widely discussed in European countries. The two terms are well established in relation to the hazards associated with the use, storage and transport of dangerous substances and in a number of countries also with respect to the protection of critical infrastructures, where the recommendations and guidelines of the "European Programme for the Protection of Critical Infrastructure" are accepted and implemented in national laws. State-of-the-art guidelines are available, which have to be considered by national governments and operators.

The turn from so-called "absolute safety" to "risk awareness" has been made. Risk assessment and risk analysis are carried out with quantitative, semi-quantitative and qualitative concepts. In the qualitative approaches, risk assessment is very much dependent on experts opinions and proposals. Criteria are defined and measures taken in accordance. Quantitative risk assessment is applied in terms of numbers and comparability.

The Seveso III guidelines directed by the European Union have to be adopted on national levels until 2015 to enforce risk assessment and management of dangerous substances. National governments are aware of dangers related to critical infrastructures (CIs) of the type of chemical industries, and thus are regulating critical incident management on this behalf.

Natural hazards are partly covered with the Eurocodes. Actions on structures are defined and structural design has to be in accordance with guidelines. Countries identify national seismic hazard levels in their national appendices of the Eurocode. The European Seismic Hazard Project SHARE represents a trend-setting approach on how to harmonize different national standards.

In terms of risk assessment, the level of detail regarding the methods to be used and the criteria to be observed when dealing with risk vary widely. In the cases where methods are prescribed or advised they all comprise the following elements:

1. Identification of hazard (installation / critical infrastructure);
2. Find the threat or cause that might release the hazard (industrial accidents, natural or man-induced disasters) and assess the likelihood;
3. Asses the (extent of the) damage (casualties, disruption, economic losses…) (Parts 1-3 can be seen as scenario building);
4. Evaluate the scenarios: Do they require any measures? In this evaluation a combination of the likelihood and severity of the consequences will be considered;
5. Decide which action should be taken to deal with the risk.

A harmonized approach (e.g. STREST) comparable to the Eurocodes in the building industry could significantly increase public discussion and acceptability on how to deal with any type of risk related to Critical Infrastructures in the European Union.

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Appendix A: Risk assessment methods

HAZARD AND OPERABILITY STUDY (HAZOP)

The HAZOP assessment method is a structured and systematic examination method to identify and evaluate incidents, which emanate risks. The method deals in principle with the terms "prediction", "locating causes" and "estimating the consequences" of risks. Counteractive measures are applied. The comparison with the allocated targets and the actual targets is made. The HAZOP method is executed under the guidance of experts and conducted in structured discussions. Thus, the method not only depends, but also relies, on experience of involved people. The HAZOP team then determines possible significant deviations from any defined measures, which likely cause and result in negative consequences. It is then decided whether existing and designed safeguards are sufficient, or if additional actions are required to reduce risks to an acceptable level. The HAZOP method to assess risks is a qualitative method.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

The FMEA method involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes. This is done with analytic methods to assess reliabilities. Its basic principle is to avoid failures already prior to their appearance. Selections and discussions are led by teams of experts.

Classification numbers ("consequences", "probability of occurrence" and "probability of discovery") are the basis for the risk evaluation. These numbers represent values in an ordinal scale between 1 and 10 and are defined based on rating recommendations. The "risk-potential-number" is then defined by the multiplication of the three factors, resulting in a possible value to classify and arrange risks. The expressions of estimated risks are assigned from the perspective of society/environment that would be affected by consequences. FMEA is a "bottom-up" method.

FAULT-TREE ANALYSIS (FTA)

The FTA method is based on Boolean decision-making with the intention to evaluate blackout probabilities. These could be caused by initiating faults and events in complex systems. Based on logic relations (the system is either in the status functional deficiency or functional capability), the branches in the fault tree are identified, which yield the highest risks and/or worst consequences.

Fault trees can be based on large numbers of event occasion combinations, which are then evaluated with the use of computer software. The analysis has been used in probabilistic approaches in the nuclear industry. In Germany, the DIN 25424 covers the FTA method. It is a "top-down" method.

EVENT-TREE ANALYSIS (ETA)

The ETA method is used to find a path to assess probabilities of outcomes and overall system analysis. It is based on the occurrence of both a functioning or not functioning system, given that an event has occurred. The ET analysis works by tracing forward in time, which is in difference to the FT analysis. Similarly, the two methods are both based on analytical diagrams using Boolean logic. The ET analysis is a "bottom-up" method.

An event-tree is built up on possible paths of events. From these, probabilities of occurrence can be estimated. The event, which results in the highest risks and/or consequences can be easily identified. Additionally, measures can to taken in order to avoid the occurrence and/or their effect can be graphically and mathematically estimated.

RISK MATRIX (RM)

The risk matrix defines the relationship between the likelihood of an incident and the consequences caused by this incident. A diagram is assembled, in which the first axis shows the possible amount of damage and the second axis shows the probabilities of this events occurrence. In the diagram, classifications are made based on priority rating. Based on these ratings, priority decisions can be made.