Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Free State of SAXONY

Umwelt Bundes Amt — For our Environment

OECD

OECD Workshop

Natech Risk Management

Natural Hazards Triggering Technological Accidents

23rd to 25th May 2012

at Dresden, Germany, International Congress Center

Refinery and Shipping Facilities at SENDAI, Japan (March 12th, 2011)

Workshop Proceedings

- Programme
- Natech Risk Reduction in OECD Member Countries
- Discussion Document
- Abstracts
- List of participants

Dessau-Roßlau, 2012

Dresden, Germany

Umweltbundesamt (Federal Environment Agency)
Division III 2.3 Safety of Installations
Wörlitzer Platz 1
D-06844 Dessau-Roßlau

Time		Room	Doc	
Tuesday, 22th May 2012				
14:00	~ 16:00	**Bus Departure:** Main Entrance Congress Center		**Excursion to the site of Flourchemie Dohna** (Natech Risk Management at a site threatened by flashfloods (presentation II.2)
16:00	20:00	Foyer Hall Level		**Registration and workshop documents** GFI Umwelt, Bonn, Germany
19:00	20:00	Hall 4		**Meeting of the chairs, speakers, rapporteurs, consultant** **Roland FENDLER** (Federal Environment Agency (UBA), Germany)
Wednesday, 23th May 2012				
08:00	09:00	Foyer Hall Level		**Registration, distribution of badges and workshop documents** GFI Umwelt, Bonn, Germany
09:00	**10:00**	**Hall 5**		**OPENING SESSION: Welcome & Introduction**
				Ruth OLDENBRUCH (Federal Ministry for the Environment, Germany)
				State Secretary Dr. Fritz Jaeckel (Ministry for the Environment and Agriculture, Free State of Saxony)
				Marie-Chantal HUET (OECD)
09:15	09:30		**QS**	**Natech Risk Reduction in OECD Member Countries: Results of a Questionnaire Survey** Elisabeth KRAUSMANN (EC Joint Research Center)
09:30	10:00		**DD.**	**Presentation of the Discussion Document** Karl-Erich KÖPPKE (Consultant, Dr. Köppke GmbH, Germany)
10:00	**13:30**	**Hall 5**		**SESSION I: Natural Hazards: Mapping and Warning Systems** **Chair: C1 Georg BÖHME-KORN** (Saxon State Ministry of the Environment and Agriculture) **Rapporteur: Daniel BONOMI** (Federal Office for the Environment (FOEN), Switzerland)
10:00	10:40			**I a Presentation 1.1 - 1.2: Natural Hazard Mapping**
			I.1	**P1.1 Hazard and Risk Maps as a Main Element of Flood Risk Management: Lessons Learnt after 2002 Flood in Saxony** **SP1.1** Martin SOCHER (Saxon State Ministry of the Environment and Agriculture)
			I.2	**P1.2 Principles of Risk Management for Natural Hazards: The Case of Switzerland** **SP1.2** Hans KIENHOLZ (KiNaRis, Switzerland)
10:40	11:00			**Discussion**
11:00	**11:30**	**Foyer**		**Coffee Break**

Time		Room	Doc	
11:30	12:10			**I b Presentation 1.3 – 1.4: Natech Risk Mapping**
			I.3	**P1.3 Use of GIS and Conceptual Mapping in Identification and Monitoring of Natech Risks** **SP1.3** Aleksandar JOVANOVIC (European Virtual Institute for Integrated Risk Management)
			I.4	**P1.4 RAPID-N: A Tool for Mapping Natech Risk Due to Earthquakes** **SP1.4** Serkan GIRGIN (EC Joint Research Center)
12:10	12:30			**Discussion**
12:30	**13:30**	**Hall Level Restaurant**		**Lunch**
13:30	**18:30**	**Hall 5**		**SESSION II: Natech risk management (including emergency planning) – Best practices of industry and authorities** **Chair: C2 Christian JOCHUM** (European Process Safety Center) **Rapporteur: Elisabeth KRAUSMANN / Agnes VALLEE / Roland FENDLER** (EC, Joint Research Center/ INERIS, France/ Federal Environment Agency, Germany)
13:30	15:10			**II a Presentation 2.1 - 2.5.: Flood Risks**
			II.1	**P2.1 NATECH accidents in Czech Republic: Lessons learned and Related Research** **SP2.1** Pavel DANIHELKA (Technical University of Ostrava, Czech Republic)
			II.2	**P2.2 The Flood 2002 – Experiences of a Hydrofluoric Acid Producing Plant** **SP2.2** Christian WEISS (Fluorchemie Dohna GmbH, Germany)
			II.3	**P2.3 French Regulation for Integration of Natural Hazards in Industrial Safety Assessment – Choice of Reference Scenarios to Characterize these Natural Phenomena** **SP2.3** Cédric BOURILLET (French Ministry of Ecology, Sustainable Development, Transports and Housing)
			II.4	**P2.4 Methodology for Integration of Flood Hazard in Industrial Safety Assessment** **SP2.4** Agnes VALLEE (Institute on Industrial Risk – INERIS, France)
			II.5	**P2.5 The German Technical Rule for Process Safety: Prevention and Preparedness due to Hazards by Precipitation and Floods.** **SP2.5** Karl-Erich KOEPPKE (Dr. Köppke GmbH, Germany)
15:10	15:40			**Discussion**
15:40	**16:10**	**Foyer**		**Coffee Break**

Time		Room	Doc	
16:10	17:30			**II b Presentation 2.6 – 2.10: Earthquake Risks**
			II.6	**P2.6 Natech Accidents due to the 11 March 2011 Earthquake and Tsunami and Follow up** **SP2.6** Yuji WADA (National Institute of Advanced Industrial Science and Technology (AIST), Japan)
			II.7	**P2.7 Lessons from the Sendai Industrial Complex and Chiba's Cosmo Oil Refinery Fires Following the Great Eastern Japan Earthquake and Tsunami.** **SP2.7** Ana Maria CRUZ NARANJO (Consultant, Université de Bordeaux I)
			II.8	**P2.8 The Natech Events During the 17 August 1999 Kocaeli Earthquake: Aftermath and Lessons Learned** **SP2.8** Serkan GIRGIN (EC Joint Research Center)
			II.9	**P2.09 New French Seismic Regulation for Hazardous Industrial Facilities** **SP2.09** Adrien WILLOT (Institute on Industrial Risk – INERIS, France)
17:30	18:30			**Discussion**
18:30		Conference Office 3.40		**Meeting of Consultant and Rapporteurs**
20:00	**22:30**	**Hotel Rest.**		**Dinner - Reception at the Conference Hotel**

Time		Room	Doc	
Thursday, 24th May 2012				
08:30	11:00	Hall 5		**SESSION II: Natech Risk Management (Including Emergency Planning) – Best Practices of Industry and Authorities** - continued -
08:30	08:50			**II c Presentation 2.10: other Hazards**
			II.10	**P2.10 Seveso Directive Plants Threatened by Bush Fires: Analysis on Several Reported Cases and Guidelines Proposal** **SP2.10.** Jean-Paul MONET (French Fire and Emergency Management Service)
08:50	09:00			**Discussion**
09.00	10:20			**II d Presentation 2.11 – 2.14: Methodology**
			II.11	**P2.11 Proposal of Methodology for Combined Natural and Technological Risks Identification and Assessment.** **SP2.11** Pavel DOBEŠ (Technical University of Ostrava, Czech Republic)
			II.12	**P2.12 A Bow-tie for Natech: Approaching the Quantitative Assessment of Risk Associated to Natech Scenarios.** **SP2.12** Valerio COZZANI (University of Bologna, Italy)
			II.13	**P2.13 The Challenge of Making 'Typical and Atypical' Major Hazard Szenarios in the Chemical Industry** **SP2.13** Richard GOWLAND (European Process Safety Center)
			II.14	**P2.14 Lessons Learnt from Natural Disasters** **SP2.14** Charles COWLEY (Center for Chemical Process Safety, USA)
10:20	11:00			**Discussion**
11:00	**11:30**	Foyer		**Coffee Break**
11:30	**13:30**	**Hall 5**		**SESSION III: Consideration of Climate Change in Natech Risk Management** **Chair: C3 Manfred STOCK** (Potsdam Institute for Climate Impact Research (PIK), Germany) **Rapporteur: Roland FENDLER / John BREWINGTON** (Federal Environment Agency, Germany / Environment Agency, UK)
11:30	12:50			**Presentation 3.1 – 3.4**
			III.1	**P3.1 New Results on Extreme Events** **SP3.1** Udo MELLENTIN (Saxon Agency for Environment, Agriculture and Geology)
			III.2	**P3.2 Adaptation Measures of the Oil and Gas Industry** **SP3.2** Ana Maria CRUZ NARANJO (Consultant, Université de Bordeaux I)
			III.3	**P3.3 Engagement of BASF in Adaptation to Climate Change** **SP3.3** Monika BAER (BASF AG)
			III.4	**P3.4 National Grid's Climate Change Adaptation Journey** **SP3.4** Gary THORNTON (National Grid, UK)
12:50	13:30			**Discussion**
13:30	**14:30**	**Hall Level Restaurant**		**Lunch**

Time		Room	Doc	
14:30	**15:30**	**Hall 5**		**SESSION IV: Application of the Polluter-Pays-Principle (PPP) to Natechs** **Chair: C4 Peter KEARNS** (OECD) **Rapporteur: Marie-Chantal HUET** (OECD)
14:30	15:10			**Presentation 4.1 – 4.2**
			IV.1	**P4.1 Polluter-Pays-Principle, Tort Law, Natural Catastrophes and Liability Insurance** **SP4.1** Christian LAHNSTEIN (Munich Re, Germany)
			IV.2	**P4.2 Role of Insurance When the Polluter Pays** **SP4.2** Judith GOLOVA (MARSH Insurers, UK)
15:10	15:30			**Discussion**
15:30	**16:00**	**Foyer**		**Coffee Break**
16:00	**19:00**	**Hall 5**		**SESSION V: International Co-operation on Natech Risk Management** **Chair: C5 Mark HAILWOOD** (State Institute for Environment, Monitoring and Nature Conservation Baden-Württemberg) **Rapporteur: René NIJENHUIS** (UNEP/OCHA Environmental Emergencies Section)
16:00	17:00			**V a Presentation 5.1 - 5.3 International Projects**
			V.1	**P5.1 Needs Assessment Study on Chemical Accidents Prevention and Preparedness in Region 8, Phillippines** **SP5.11** Jean C. BORROMEO (Philippine Department of Environment and Natural Resources)
			V.2	**P5.2 Apell Process in Sri Lanka: Preparation of Integrated Emergency Preparedness Plans for Two Selected Industrial Zones** **SP5.12** Jayavilal FERNANDO (Central Environmental Authority, Sri Lanka)
			V.3	**P 5.3 Projects of the UNECE Convention of the Transboundary Effects of Industrial Accidents to Support Prevention, Preparedness and Response to Natechs** **SP5.3** Chris DIJKENS / Viginia Fuse (UNECE Chair of the Conference of the Parties / UNECE)
17:00	17:30			**Discussion**
17:30	18:10			**V b Presentation 5.4 - 5.5 International Assistance**
			V.4	**P5.4 International Chemical Environment** **SP5.4** Jos VERLINDEN (cefic)
			V.5	**P5.5 The Hazard Identification Tool (HIT) – a Tool to Identify and Address Secondary Environmental Risks** **SP5.5** Dennis BRUHN (OCHA Environmental emergencies section)
18:10	18:30			**Discussion**
19:00		Conference Office 3.40		**Meeting of Consultant and Rapporteurs**
19:00	**20:30**			**Reception by the Government of Saxony** **(at the Sächsische Staatskanzlei Archivstr.1 see: page 8)**

Time		Room	Doc	
Friday, 25th May 2012				
09:00	**13:30**	**Hall 5**		**Conclusions and Recommendations** **Chair: Roland FENDLER** (Federal Environment Agency, Germany) **Rapporteurs**
09:00	09:30		**S1**	**Presentation of C&R from Session I** **Discussion**
09:30	10:30		**S2**	**Presentation of C&R from Session II** **Discussion**
10:30	**11:00**	**Foyer**		**Coffee Break**
11:00	11:30		**S3**	**Presentation of C&R from Session III** **Discussion**
11:30	12:15		**S4**	**Presentation of C&R from Session IV** **Discussion**
12:15	13:00		**S5**	**Presentation of C&R from Session V** **Discussion**
13:00			**F**	**Farewell**
13:00				**Transfer to Dresden Airport** GFI Umwelt, Bonn, Germany

A. Sächsische Staatskanzlei
Archivstr 1
01097 Dresden

Natech Risk Reduction in OECD Member Countries: Results of a Questionnaire Survey[1]

Natech Risk Reduction in OECD Member Countries: Results of a Questionnaire Survey

Elisabeth KRAUSMANN (EC, Joint Research Center)

The European Commission's Joint Research Centre (JRC) carried out a questionnaire survey to assess Natech risk management practices and awareness of Natechs, collect case histories and lessons learned, and identify needs and/or limitations in implementing Natech risk reduction strategies in European Union Member States and OECD Member Countries. The results of the survey are intended to lead to better designed and targeted Natech risk reduction strategies. The questionnaire was sent to the members of the OECD Working Group on Chemical Accidents (WGCA), with a request to complete the questionnaire and involve other stakeholders in their countries if deemed necessary. A total of 20 OECD Member Countries returned the completed questionnaire. These countries are (in alphabetical order): Australia, Austria, Czech Republic, France, Germany, Iceland, Israel, Italy, Luxemburg, Netherlands, New Zealand, Norway, Poland, Slovakia, South Korea, Sweden, Switzerland, Turkey, United Kingdom and The United States of America.

The analysis showed a clear tendency towards recognising natural hazards as an important external risk source for chemical facilities and 40% of the responding countries declared to have suffered one or more Natech accidents with the release of toxic substances, fires and/or explosions and sometimes fatalities and injuries between 1990 and 2009.

Many survey respondents indicated that the improvement of existing regulations, as well as their enforcement, and the preparation of specific technical codes and guidelines would be required to fully address Natech risk in their country. While a legal framework for Natech risk reduction exists via the responding countries' chemical-accident prevention programmes, the effectiveness of these programmes in mitigating Natech risk is largely inconclusive. The occurrence of Natech accidents indicates that there may be gaps in legislation, implementation and/or its monitoring that should be addressed to ensure effective Natech risk reduction. It is interesting to note that Natech risk is hardly addressed in natural-disaster management regulations. Technical codes and standards for the design, construction and operation of buildings and structures in industry consider certain natural hazards but their ultimate goal is the safety of human life. Therefore, the prevention of hazardous-substance releases may not be guaranteed and secondary risks due to these releases may not be taken into account. Additionally, some of these technical codes and standards may not be suitable for controlling risks due to hazardous substances. Specific guidelines for Natech risk reduction to support legislation are scarce.

Awareness of Natech risk seems to be increasing within the countries' competent authorities although there is uncertainty as to the current level of knowledge on the dynamics of Natech accidents and the extent of training on Natech risk reduction. The latter was mentioned as one of the priority needs to be addressed by the survey respondents. It was felt that there may be a lack of awareness in industry, and in 40% of the responding countries industry appears to insufficiently take Natech risk into account during the industrial risk assessment process. In addition, there is a reported lack of Natech-specific scenarios. Low levels of Natech preparedness could therefore result. This highlights the need for better risk communication and the development of methodologies and tools for including Natech risk into conventional

[1] Basing on the second edition of the JRC Report.

industrial risk assessment. Moreover, the development of guidance on Natech risk assessment for industry was indicated as the highest-priority need for effective risk reduction, closely followed by the development of guidance on Natech risk assessment at the community level.

While Natech risk reduction measures were reported to exist, they are often generic which is not surprising due to the absence of data and models on the dynamics of Natech accidents. In fact, currently no specific Natech accident databases exist in the responding countries and Natech events have to be retrieved from conventional chemical-accident databases. Moreover, chemical-accident prevention regulations, such as the European Seveso II Directive, do not provide guidance to the operator on how Natech risk reduction should be achieved, nor to the competent authority on how to evaluate that the risk level is as low as required by regulations. This is a shortcoming that needs to be addressed. Similarly, it proved difficult to identify best practices dedicated to Natech risk reduction, with most reported examples targeted towards floods. This finding suggests that the availability of Natech-specific best practices may be limited at present and efforts should be directed towards filling this gap. Another priority need expressed by the survey respondents is the development of specific Natech risk maps which are to date barely available. These are required for the identification of Natech-prone areas to inform land-use-planning and emergency-management decisions. In contrast, many countries have developed natural hazard or risk maps for selected natural hazards in certain regions.

The results of this Natech questionnaire survey show that natural events have been recognised as a relevant source of risk to a chemical facility with the potential to trigger a major accident. However, the survey highlighted a number of research and policy challenges and gaps that hamper effective Natech risk reduction. The following areas for future work have been identified (in arbitrary order):

- Improvement of awareness raising and risk communication at all levels of government (national, regional, local) and in industry;
- Implementation and enforcement of specific regulations for Natech risk reduction;
- Preparation of guidelines for risk assessment in industry and specific technical codes that address Natech risk;
- Preparation of dedicated Natech emergency management plans which consider the possible lack of utilities;
- Development of Natech risk maps for effective land-use planning and emergency management;
- Development of guidance on Natech risk assessment at the community level;
- Land-use planning that explicitly addresses Natech risk;
- Training of competent authorities on Natech risk reduction both in the chemical-accident prevention and the natural-disaster management communities.
- Development of methods and tools for Natech risk assessment;
- Identification of best practices for Natech risk reduction and sharing of existing practices with other countries;
- Research into the impact of climate change on future Natech risk;

In addition to the above points it is recommended that lessons learned from the analysis of past Natech accidents should be formulated and disseminated widely. These lessons should address failure modes and hazardous-substance release paths as a function of natural-hazard severity, as well as identify risk-reduction measures and possible best practices. Moreover, indicators for measuring the effectiveness and adequacy of Natech risk-reduction measures should be developed.

It should be noted that over half of the responding countries have launched research activities and programmes to address the problem of Natech accidents. It is hoped that the findings of this report could help focus these research efforts in a productive way and foster multi-lateral collaboration in appropriate areas, such as data collection and analysis, the identification of best practices and the development of performance measures. Many of the above proposals could be addressed within the Natech Project Steering Group of the OECD WGCA if desired. Moreover, it is proposed that the relevant chapters in the OECD Guiding Principles on chemical accident prevention, preparedness and response be adapted to more explicitly consider Natech risk.

The JRC report on the results of the Natech questionnaire survey was reviewed and accepted by the Steering Group of the OECD WGCA Natech project, of which the JRC is a member, and it´s first edition welcomed by the 19th Meeting of the OECD Working Group on Chemical Accidents in October 2009.

Discussion Document

Prof. Dr. Erich KÖPPKE (Dr. Köppke GmbH, Germany)

Contents

Session I: Natural Hazards: Mapping and Warning Systems

Hazard and risk maps and early warning systems are important elements of Natech risk management of authorities and operators.

Early warning systems are short-term systems which can be used by operators, e.g. for shut-down or evacuation procedures.

Hazard Mapping

Hazard maps are necessary for the authorities and operators for land-use planning, siting of facilities (e.g. in case of earthquake and flood hazards), layout of installations, enforcement of regulations and design codes (e.g. for buildings in order to improve earthquake resistance), dimensioning of private and public protection and prevention measures (e.g. dikes in case of flood hazards) and to prepare for response and mitigation activities including emergency planning. In some countries hazard maps are provided for most of the relevant natural hazards. As examples the following hazard maps have been elaborated in different countries:

- Flood maps
- Landslide maps
- Earthquake maps
- Liquefaction susceptibility maps
- Wind and storm maps
- Rainfall maps
- Snow load maps
- Avalanche maps

Hazard maps have to be supplied by the national authorities. The quality of the different maps mainly bases on the available data of recent events and the statistical analysis of these events. The maps must be elaborated, actualized from time to time and disseminated to the different users. Dissemination is mostly carried out via internet.

The basis of hazard mapping can differ in the OECD-countries. There is no consistent requirement for hazard mapping like in the European Union for flood hazard and risk maps.[2]

According to European Flood Risk Management Directive 2007/60/EC *on the assessment and management of flood risks* flood hazard maps have to be provided in the EU member countries for

- floods with a low probability, or extreme event scenarios
- floods with a medium probability (likely return period $\geq$ 100 years);
- floods with a high probability, where appropriate.

The extreme event scenarios can be used by the plant operators to assess the impact of a flood on the site and installations. With this information the plant operator is able to design protections measures in

[2] EXIMAP: Handbook on good practices for flood mapping in Europe. 2007, http://ec.europa.eu/environment/water/flood_risk/flood_atlas/pdf/handbook_goodpractice.pdf

order to mitigate the risk of damages with release of chemicals and to elaborate management plans. Therefore, hazard maps including extreme events should be provided by the authorities.

An analysis of the legal requirements shows that in most of the OECD member countries extreme natural events must not be considered by the plant operators in accident prevention. Furthermore, natural hazard maps which illustrate endangered areas caused by different natural hazards do not generally present extreme events of low probability.

An example of best practice for hazard maps supply and dissemination is the Federal Office for the Environment (FOEN) of Switzerland. FOEN provided a map with all locations of possible emissions of chemicals. This map can be mixed with the different natural hazards maps (e.g. earthquake and/or flood) but also with maps of historical events. To each historical event special information is provided in this interactive system.

Furthermore, the time of return for flood can by varied between 50 years and 500 years. The map scale can be adjusted by the user to receive exact information with high resolution about potential natural hazards in the regarded location.

Early Warning Systems

Early warning systems are developed for different natural hazards like extreme weather, floods, tsunami, and earthquakes. All systems are generally based on the following elements, illustrated in **Figure 1.**

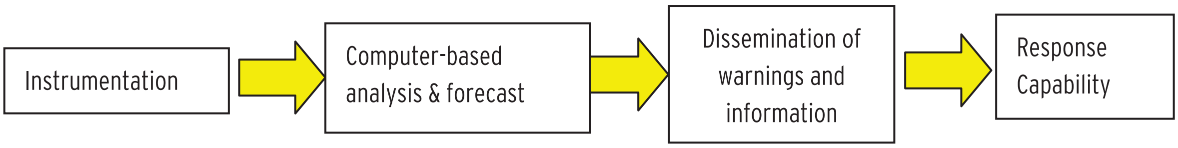

Figure 1: *Element of early warning systems*[3]

The main problem of all systems is the reliability of the results, especially for forecasts of earthquakes. Existing short-term forecasts[4] can be useful and have shown their success in some cases. But due to uncertainties a rate of failure and false alarms must be tolerated. The uncertainty of short-term predictions mainly depends on local conditions, equipment used for detection and measurement, availability of data, reliability of validated computer models and parameters, which must be assumed in the different computer based models.

Early warning systems for extreme weather and floods are much more precise in comparison to earthquake forecasts.

Nevertheless, short-term forecasts are useful in countries, where inhabited areas are at high risk of natural hazards. If industrial facilities are in this areas and cause a high Natech risk, a certain level of false alarms, e.g. in case of earthquakes, should be tolerated by the industry.

Early warning systems for earthquake forecast are installed in many countries, e.g. California (USA), Mexico, Turkey, Japan, Greece, Romania etc. Some of these systems are shortly presented in the background information of this discussion paper. All systems have a forecast time of few seconds.

Tsunami forecasts base on the measurement and localisation of the epicentre of an earthquake and the measurement of the tsunami. The warning time depends significantly on the distance between the epicentre and the potential affected coast.

3 According to United Nations: Global Survey of Early Warning Systems, Sept. 2008
4 The term „nowcast“ is used for metrological forecasts for six hours or less.

In comparison with early warning system for earthquakes the forecast time of hurricanes is much longer (hours up to days), because origin, growth and path of the hurricane can be observed by satellite systems or ground based observation stations. Path prediction is still problematic and cannot exactly be calculated.

In the USA the warning time of tornados is 13 minutes on average. Most of the forecasts in the USA base on the 121 radar measurement stations.

A new system of a local early warning system for extreme weather was developed with the project SAFE in Germany. The SAFE project combines distributed weather sensor networks with improved, location-specific weather prognosis modules and an early warning messaging system. This messaging system is used to provide both the general public and emergency services with personalized, situation-dependent information on upcoming extreme weather conditions.

Furthermore, SAFE is able to steer remote-controlled actuators that induce automated countermeasures, such as closing open windows, retracting blinds, or disconnecting sensitive electronic equipment from the power grid.

Issues Requiring Further Discussion

1. Should data collection, data analysis and dissemination of information about natural hazards be national assignments of the countries and authorities?
2. Should requirements for hazard and risk mapping of natural events be required in national legislation?
3. What is best practice in communication of natural hazard maps to operators, communities and public?
4. Should an internationally coordinated guideline be provided for natural hazard mapping?
5. Should - in general - consideration of the different hazard sources be done in cooperation with adjacent countries, e.g. for river basin management activities? (compare EU Water Framework Directive[5] and EU Directive on the assessment and management of flood risks[6])
6. Are special Natech risk maps useful for special cases?
7. Under which conditions makes it sense to recommend early warning systems (e.g. tsunamis)?
8. Which failure rate of alarms and warnings is required to apply these systems successfully in industry?

[5] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, 2000

[6] Directive 2007/60/EC on the assessment and management of flood risks, 2007

Session II: Natech Risk Management

Need of a general approach for Natech Risk Management

One of the principal problems of Natechs is the simultaneous occurrence of a natural disaster and a technological accident. Both require simultaneous response efforts in a situation in which lifelines needed for disaster mitigation are likely to be unavailable.

The difficulties to develop methods and procedures for Natech risk assessment are still relevant due to different factors:

a) Complexity of these phenomena, deriving from the interaction of different hazard sources - natural and technological - which can impact the same objects in a different way, simultaneously or within a short time frame.

b) Heterogeneous competencies are required in order to deal with Natechs; it is necessary to share knowledge in the field of both natural and technological risk assessment and management and, up to now, these fields have been scientifically and operatively separated.

Krausmann et al.[7] state that "recent studies have indicated that legislation and standards for chemical-accident prevention do not explicitly address Natech risk. In addition, methodologies and tools for the assessment of Natech risk are scarce, and only limited guidance for industry and the authorities on how to assess Natech risk is available. With climate change predicted to increase the frequency of severe hydro-meteorological events, Natech risk is expected to increase in the future. This highlights the need for the development of tools for industry and authorities to assist in the analysis of the risk in chemical installations and infrastructures due to Natech accidents."

Chemical-accident prevention and pollution-control regulations, such as the Seveso II Directive, do not provide guidance to the operator on how Natech risk reduction should be achieved, nor to the competent authority on how to evaluate that the risk level is as low as required by regulations. Additionally, some of the existing technical codes and standards may not be suitable for controlling risks due to hazardous substances. Specific guidelines for Natech risk reduction to support legislation are scarce. These results were confirmed in other studies.[8] Therefore, the development of specific technical codes and guidelines would be required to fully address Natech risk.

Hazard identification and risk assessment are generally described in Chapter 2 b of the OECD Guiding Principles for Chemical Accident, Prevention, Preparedness and Response (2003). Natech risks are not directly subject of the explanations of the requirements for risk assessment in this guidance.

Krausmann et al. state that a specific approach for Natech risk assessment is needed, because the standard risk management procedure does not cover the special recommendations for Natech risk assessments.[6]

Based on new experiences some countries have realized the problem and have integrated the consideration of natural hazards in the management of industrial safety (e.g. in safety documents) and in their national regulations during the last years. In France for example specific regulations or good practices

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7 Krausmann, E; Cozzani, V.; Salzano, E; Renni, E.: Industrial accidents triggered by natural hazards: an emerging risk issue. Nat. Hazards Earth Syst. Sci., 11, 921–929, 2011

8 Warm, H.J.; Köppke, K.-E.: Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Safety of new and existing facilities and establishments against natural environmental hazards, especially floods). German Federal Environment Agency, 2007, Ref.-No. 203 48 362

for hazardous industrial facilities exist for earthquake, lightning, flooding, snow and wind. For other natural hazards not listed above, such as avalanche, volcanic eruption, there are no national specific regulations or best practices to their consideration. In these cases, the integration of these natural phenomena in the safety report is left to the discretion of the operator.

In Germany the Technical Rule for Plant Safety 310 considers the possible increase of hazards by precipitation and floods due to expected climate change.

Although different hazard specific approaches of risk assessment for land-use planning, siting of facilities, flood and precipitation, earthquakes, and tsunami impacts are developed, no defined general procedure for Natech risk assessment exists, which includes general necessary working steps.

Examples of best practice for Natech risk assessments are presented in the following chapters.

Risk assessment of earthquakes in France

A new regulation (Decrees 2010-1254 and 2010-1255, dated October 22nd 2010) recently introduced a new zoning for seismic activity, dividing France into 5 areas, from areas 1 (very low seismic activity) to 5 (high activity). This regulatory change bases new scientific knowledge, which has led to a re-evaluation of seismic hazard and a re-definition of the zoning based on a probabilistic approach (taking into account the return periods).

In this context, industrial facilities in France are classified according to the properties of the handled/stored chemical products or according to their activities ("classified sites"). With regards to the regulation which establishes the rules for protection against earthquake, the classified sites may be subject to regulation applicable to "normal risk" or "special risk" installations. According to the Ministerial Order of 24th January 2011, "special risk" classified sites are pieces of equipment in low and upper-tier SEVESO establishments that may lead, in case of an earthquake, to one or more dangerous phenomena with lethal effects out of the site boundaries, unless there are no permanent human presence in this identified lethal effects area.

The elastic response spectra (vertical and horizontal) in acceleration, representing the seismic movement of one point in the surface on the right of the establishment are then elaborated, using information given in the Ministerial Order.

If the installation is new, compliance to regulation must be demonstrated when the operator submits a request for a permit to operate. Protective measures against the earthquake must then be implemented at the start of operations.

For existing establishments, a study to assess the technical measures necessary to protect from earthquakes must be carried out before December 31st 2015, and the implementation of these measures must not exceed 1st January 2021.

All other pieces of equipment in establishments that do not belong to the "special risk" category are considered as "normal risk" category. In this case, classified sites must apply the Order of 22nd October 2010 like all buildings on French territory. There are rules for new buildings, or existing buildings in specific conditions, in seismic area 2, 3, 4 and 5. The application of Eurocode 8 is required, while leaving the possibility of using standard rules in the case of simple structures. The protection level is adjusted according to the structure involved.

Risk Assessment for Precipitation and Floods in Germany

In 2012 the new Technical Rule for Plant Safety 310 was published by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. This Technical Rule considers the possible increase of hazards by precipitation and floods due to expected climate change.

The methodical procedure bases on four main steps:

1. Hazard source analysis, in which it is scrutinized what hazard sources could affect the site singly or in combination,
2. Analysis of hazards and threats, in which it is scrutinized whether major accidents may occur as a result of effects on safety-relevant parts of an establishment or installations,
3. Drafting of a protection concept, in which precautions to prevent major accidents are specified,
4. Examination of 'major accidents despite precautions', which leads in particular to the specification of measures to mitigate the effects of major accidents.

At the beginning of the hazard source analysis the operators have to determine possible hazard sources. Initially, a simplified hazard source analysis only identifies events in qualitative terms at the location (incl. establishments) that are possible (cannot reasonably be excluded) within the region. In a detailed hazard source analysis, further information is drawn upon in order to determine possible hazard sources more accurately.

Where hazard sources cannot reasonably be excluded, a detailed hazard source analysis is required. The foreseeable consequences of climate change should be taken into consideration in the course of a hazard source analysis, even if uncertainties naturally attach to them. With the global temperature rising as a consequence of climate change, the atmosphere's capacity to absorb water vapour will increase disproportionately. This gives reason to expect that the intensity and frequency of heavy precipitation will rise in line with the rise in temperature.

The risk assessment to be performed bases on the fact that an inundation only occurs, if the water inflow into an area is greater than the outflow. So the inflow and outflow streams must be identified.

Flood maps based on different probabilities and provided by the authorities give important information to the operators in order to perform a water balance. Data about precipitation with different intensities and recurrence intervals provided by DWD (Deutscher Wetterdienst) can easily be interrogated for the local conditions of a plant. Other information sources are topographic maps and experiences from recent events. The percolation rate of the surface water in the surroundings of the plant must be estimated. In case of covered surfaces the runoff factor is close to 1. The impact of subways, and raised railway lines or streets as barriers for runoff water must be considered. Also possible bottlenecks for the runoff water like small bridges must be identified, as floating refuse can decrease the water flow.

With this information a hazard assessment can be performed. Furthermore, with an extrapolation of the precipitation ratios extreme events can be simulated and assessed. In order to prove the results of the hazard source analysis some parameters can be varied, e.g. the percolation rate to the ground.

In the second step the endangered installations and establishments of a plant can be easily identified with the help of the calculated water depths. Using different scenarios the impact of the water on installations and establishments can be estimated.

During the third step a protection concept based on the legal requirements must be elaborated. Protection concepts are to be developed on the basis of the hazard sources that cannot reasonably be excluded, the hazards or threats that are identified, and the scenarios and protection aims. When protection concepts are elaborated, attention is to be paid to the requirement laid down in Article 3(4) of the Major

Accidents Ordinance that they be consistent with the state of the art of safety technology. For the purposes of adaptation, climate change is to be taken into consideration in defining protection aims.

Step four requires the examination of 'major accidents despite precautions'. Such events occur, if all precaution measures fail. Especially the determination of required response and mitigation measures including emergency planning should base on assumed effects of extreme events.

This shortly described procedure was tested successfully for a plant of the chemical industry.

Risk Assessment for Flood in France

International databases show that floods accounted for more than half of disasters registered for the 1990-2001 period. With consequences of climate change largely unpredictable at local level, future statistics are not likely to show any improvement. In response to such natural-technological interaction, mitigation efforts have taken two main directions: land-use planning in flood-prone areas; vulnerability reduction in flood-prone facilities. This communication focuses presents good practice accumulated in France for the mitigation of flood impacts on industrial facilities.

INERIS[9] proposes to present a methodology for the integration of flood hazard in risk-reduction process for industrial plants. Both floods originated from a dam rupture and unusual rainfalls will be considered.

This methodology follows a sequence in 4 steps.

1. The first step aims at determining whether the studied plant is located in a floodable area or not. If it is the case, data are needed to better understand the flooding, such as type of flooding, water height, flow velocity, speed of water level rising, flooding duration, return period of flood...
2. Based on information gathered in step 1, the topography of the industrial plant, the location of buildings and facilities within plant perimeter, areas which could be affected by flooding are identified. In the potentially flooded areas, facilities and equipments that could cause major technological accidents are identified. A systematic risk analysis is then performed for each of these equipments. The accidental sequences leading to dangerous phenomena (fire, explosion, toxic cloud dispersion, pollution...) are detailed, and existing safety barriers are highlighted.
3. The safety barriers are analyzed more in details in terms or performance (efficiency, maintainability, testability...). Each barrier shall be assessed also in terms of kinetics, depending on implementation time, availability of human resources, technical devices... Depending of the available time before the arrival of water and resources in case of flooding, some safety barriers are also selected for risk assessment and emergency plan.
4. A final analysis should assess if all barriers can be implemented at the same time, taking into account the available personal and the available time between the information of flood threat and the flood itself.

A suggestion of possible safety barriers against flood will be made by INERIS.

Issues Requiring Further Discussion:

1. How to improve awareness raising on Natechs and risk communication among all stakeholders, i.e. at all levels of the government, in industry, within communities and the public?
2. What are the roles and responsibilities of key stakeholders - industry/operator, government/authorities and communities/public - in the management of Natech risks?

[9] INERIS: Institut National de l`Environnement industriel et des Risques

3. How can all parties best prepare for the challenges posed by (major) Natech risks?
4. Is there a need for training of chemical-accident and natural disaster managers and officials on Natech risk management?
5. How should Natech accidents and risk reduction be taken into account in the national chemical accidents programmes in order to guarantee effective Natech risk management?
6. Should there be an explicit legal obligation that plant operators have to consider Natechs as a part of the overall hazard identification and risk management process?
7. Should special Natech regulations and guidance provide industry/operators and authorities/inspectors, how to integrate Natech events in the existing regulations for safety management, safety reports, inspections and Natech risk assessment?
8. Should Natech regulations or guidance include the following general aspects:
    - Natech risk assessment which includes the following key aspects:
        - Identification of natural hazards,
        - Identification of endangered establishments and installations,
        - Drafting a protection concept,
        - Emergency preparedness and planning including the characteristics of Natech accidents (e.g. a possible lack of utilities);
    - Information and training of the staff, and
    - Cooperation between operators, authorities and communities?
9. How can countries share existing good practices for Natech risk reduction?
10. Should the main key points of Natech risk assessment consistently be defined by the OECD member countries in order to assure an integrative standard?
11. Which subjects related to Natechs should have priority in future Natech research?

Session III: Consideration of Climate Change in Natech Risk Management

A changing climate, including increased temperatures, changes in precipitation patterns, sea level rise, and more frequent extreme weather events will pose many challenges to industry plants. Observations show that there have been changes in weather. As climate changes, the probabilities of certain types of weather events are affected. Furthermore, kinds of natural hazards may result in regions where they have not been regarded until now. Therefore policies on the control of the impact of natural hazards on chemical installations have to take the effects of climate change on natural hazards into consideration.

The Intergovernmental Panel on Climate Change (IPCC) describes in its Fourth Assessment Report (AR4)[10]

a) observed changes in climate and their effects,

b) climate change and its impacts in the near and long term.

Observed Changes in Climate and Their Effects

Global average sea level rose at an average rate of 1.8 [1.3 to 2.3][11] mm per year over 1961 to 2003 and at an average rate of about 3.1 [2.4 to 3.8] mm per year from 1993 to 2003. Whether this faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer term trend is unclear. Since 1993 thermal expansion of the oceans has contributed about 57% of the sum of the estimated individual contributions to the sea level rise, with decreases in glaciers and ice caps contributing about 28% and losses from the polar ice sheets contributing the remainder. From 1993 to 2003 the sum of these climate contributions is consistent within uncertainties with the total sea level rise that is directly observed.

Some extreme weather events have changed in frequency and/ or intensity over the last 50 years:

- It is very likely that cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent.
- It is likely that heat waves have become more frequent over most land areas.
- It is likely that the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas.
- It is likely that the incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.

There is insufficient evidence to determine whether trends exist in some other variables, for example small-scale phenomena such as tornadoes, hail, lightning and dust storms. There is no clear trend in the annual numbers of tropical cyclones.

Climate Change and its Impacts in the Near and Long Term

The range of the projected sea level rise is from 0.18 – 0.38 m to 0.26 – 0.59 m at 2090-2099 relative to 1980-1999, depending from the scenario of greenhouse gas emissions.

These sea level projections do not include uncertainties in climate-carbon cycle feedbacks nor do they include the full effects of changes in ice sheet flow, because a basis in published literature is lacking. Therefore the upper values of the ranges given are not to be considered upper bounds for sea level rise.

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10 IPCC: Climate Change 2007: Synthesis Report

11 Numerical ranges given in square brackets indicate 90% uncertainty intervals (i.e. there is an estimated 5% likelihood that the value could be above the range given in square brackets and 5% likelihood that the value could be below that range). Uncertainty intervals are not necessarily symmetric around the best estimate.

The projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993-2003, but these flow rates could increase or decrease in the future. If this contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for IPCC Special Report on Emissions Scenarios (SRES) would increase by 0.1 to 0.2 m[12].

Projected warming in the 21st century shows scenario-independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean (near Antarctica) and northern North Atlantic, continuing recent observed trends.

It is very likely that hot extremes, heat waves and heavy precipitation events will become more frequent.

Based on a range of models, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with on-going increases of tropical sea surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period.

Extra-tropical storm tracks are projected to move toward the poles, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half century.

Increases in the amount of precipitation are very likely in high-latitudes, while decreases are likely in most subtropical land regions (by as much as about 20% in the A1B scenario in 2100), continuing observed patterns in recent trends.

Changes in precipitation and temperature lead to changes in runoff and water availability. Runoff is projected with high confidence to increase by 10 to 40% by mid-century at higher latitudes and in some wet tropical areas, including populous areas in East and South-East Asia, and decrease by 10 to 30% over some dry regions at mid-latitudes and dry tropics, due to decreases in rainfall and higher rates of evapotranspiration.

Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease. The resulting increased flood risk poses challenges to society, physical infrastructure and water quality.

It is likely that up to 20% of the world population will live in areas where river flood potential could increase by the 2080s. Increases in the frequency and severity of floods and droughts are projected to adversely affect sustainable development. Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems. The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring.

Consideration of Climate Change in Natech Risk Management

Climate change can have an effect on natural hazards threatening chemical installations. Therefore the effects of climate change have to be integrated in Natech risk management of operators, public authorities and other stakeholders. This will require:

12 New data on greenhouse gas emissions and research results on the ice flow from Greenland indicate that the sea level rise until 2100 may be underestimated in the AR4. (Presentations of Dr.-Ing. Hans Oerter and Prof. Dr. Stefan Rahmstorf in the 4th Extreme Weather Congress, 19th - 21th February 2009, Bremerhaven)

a) development of approaches for the consideration of climate change in the analysis of risks by natural hazards for regions, sites and installations;

b) methods for the consideration of climate change in the assessment of the risks by natural hazards at sites or installations;

c) development of approaches for the consideration of natural hazards and climate change in the elaboration or amendment of design and lay-out criteria, construction, rules, standards, guidelines;

d) approaches for implementation of adaptation measures at new sites or for new installations;

e) approaches for implementation of adaptation measures at existing sites or existing installations;

f) tools for the evaluation of these adaptation measures.

Issues Requiring Further Discussion

Besides the long-term global warming the climate change will influence intensity, frequency, and occurrence of extreme events. Natural hazards to be considered by the facility operators will be influenced by the effects of the climate change.

1. Should the impact of the climate change be considered by the plant operators in siting of new facilities and in the risk management?
2. Should national strategies and measures for climate change adaption consider the risk of Natechs?
3. How to deal with uncertainty of climate change projections and estimations on consequences for natural hazards in that context?
4. What assistance and guidance is needed to help operators and authorities prevent Natechs in a changing climate?
5. What is expected from research into the impact of climate change on future Natech risks?

Session IV: Application of the Polluter-Pays-Principle (PPP) to Natechs

Subject of Session IV are the OECD-Recommendations relevant for the liability of operators in case of Natechs. Main issue is how fare operators shall be held liable for the damage to persons, property and the environment due to causes of a Natech according to the national legislation. In case of Natechs the OECD Recommendations allow an exemption from this liability and the conditions of this exemption shall be further defined.

Background:

The three OECD Recommendations of the Council related to the Polluter Pays Principle (PPP)[13,14,15] issued in 1972, 1974 and 1989 respectively are important Council Acts of the OECD in the field of environmental policy.

The 1972 Recommendation on Guiding Principles concerning International Economic Aspects of Environmental Policies lays out the elements of the Polluter Pays Principle, and also pioneers the environmental links to other important concepts, such as 'harmonisation' and 'mutual acceptance'. The main idea contained in this Recommendation was that polluters themselves should bear the cost of implementing environmental protection measures that are decided by governments.

The 1974 Recommendation on the Implementation of the Polluter Pays Principle clarifies the conditions under which 'aid' provided to polluters would be considered to be in violation of the PPP, and it reinforces the view that any aid related to pollution control costs should be strictly time-limited. One question that arises, however, is whether a polluter should pay for pollution damage (residual pollution) when he has performed all the measures introduced by public authorities.

The 1989 Recommendation Concerning the Application of the Polluter Pays Principle to **Accidental Pollution** extends the PPP logic to the case of accidental pollution at hazardous installations. It is stated that "the polluter should bear the expenses of carrying out the pollution prevention and control measures introduced by public authorities in member countries, to ensure that the environment is in an acceptable state".

One exemption is:

"if the accidental pollution is caused by an event for which the operator clearly cannot be considered liable under national law, such as a serious natural disaster that the operator cannot reasonably have foreseen".

This statement would need to be developed in order to provide more guidance on these issues to public and private stakeholders.

Some guidance includes the UNECE Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters (2003) to the 1992 Convention on the protection and use of watercourses and international lakes and to the 1992 Convention on the transboundary effects of industrial accidents.

Article 4 states in "Strict liability", point 2b:

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13 OECD Recommendation (1972) on Guiding Principles Concerning International Economic Aspects of Environmental Policies [C(72)128]

14 OECD Recommendation (1974) on the Implementation of the Polluter Pays Principle [C(74)223]

15 OECD Recommendation (1989) Concerning the Application of the Polluter Pays Principle to Accidental Pollution [C(89)88]

1. "The operator shall be liable for the damage caused by an industrial accident.
2. **No liability in accordance with this article shall attach to the operator, if he or she proves that, despite there being in place appropriate safety measures, the damage was:**

a) ...

b) the result of a natural phenomenon of exceptional, inevitable, unforeseeable and irresistible character;"

The UNECE Protocol includes these four criteria in an enumeration i. e. only natural events, Natechs or damages due to Natechs are excluded **that meet all four criteria**. These four criteria can serve as a basis for further guidance for the exemption from liability in case of Natechs.

Issues Requiring Further Discussion:

The exemption from liability of operators in OECD Recommendations requires further guidance in case of Natechs.

1. Should the criteria in the UNECE protocol Protocol on Civil Liability and Compensation for Damage be used for a guidance to the OECD Recommendation Concerning the Application of the Polluter Pays Principle to Accidental Pollution of 1989?
2. Should this guidance recommend that OECD member countries only allow an exemption from liability of the operators for the damage caused by Natechs if a technical/chemical accident triggered by a natural hazard (Natech) was unforeseeable, irresistible and inevitable?
3. Should the following definitions be used in this context?

Unforeseeable: A Natech was unforeseeable if the underlying natural event had effects above those regarded as possible according to scientific knowledge, especially the effects of the natural event were above those of the most intense event recorded under similar conditions (e.g. same location) or expected due change of conditions (e.g. change in land use, climate change).

Irresistible: A Natech was irresistible if the underlying natural event had an intensity not allowing to prevent the chemical accident or mitigate its consequences according to the state of the art.

inevitable A Natech was inevitable if it was not possible to prevent the chemical accident or mitigate its consequences according to the state of the art.

Session V: International Co-operation

Background

There could be an international co-operation in

a) Management of risks due to natural hazards

b) Prevention of and preparedness for Natechs

c) Response to Natechs

Natural hazards, e.g. tsunamis and floods, which can affect huge areas in the world or regions of several countries make a transboundary co-operation necessary. There are a lot of co-operations of this type in the world like the Pacific Tsunami Warning Center, the Asian Disaster Reduction Center or the Council of the Baltic Sea States. Co-operations exist in warning systems, research and in some cases in assistance as well.

Only in some cases this includes the preparedness for Natechs too. Good examples here are the international or bilateral co-operations within river basins. Less developed is the international co-operation in Natech prevention activities although some co-operation projects may cover the aspect of Natechs as well. Transboundary co-operations without a mutual natural hazard are very seldom.

Only few cases can be found of international co-operation in response to Natechs. For example, fire fighting systems (special aircrafts, pumps, manpower) from different countries have been sent all over the world to reduce the impacts on the environment.

Article 12 and Annexe X of the UNECE Convention on the Transboundary Effects of Industrial Accidents give a legal basis for international assistance in case of Natechs.

Article 12 of the convention concerns the procedure of mutual assistance in case of an industrial accident:

Article 12. Mutual Assistance

1. If a Party needs assistance in the event of an industrial accident, it may ask for assistance from other Parties, indicating the scope and type of assistance required. A Party to whom a request for assistance is directed shall promptly decide and inform the requesting Party whether it is in a position to render the assistance required and indicate the scope and terms of the assistance that might be rendered.
2. The Parties concerned shall cooperate to facilitate the prompt provision of assistance agreed to under paragraph 1 of this Article, including, where appropriate, action to minimize the consequences and effects of the industrial accident, and to provide general assistance. Where Parties do not have bilateral or multilateral agreements which cover their arrangements for providing mutual assistance, the assistance shall be rendered in accordance with Annex X hereto, unless the Parties agree otherwise.

Details for the implementation of article 12 are given in Annex X of the UNECE-convention

1. The overall direction, control, coordination and supervision of the assistance is the responsibility of the requesting Party. The personnel involved in the assisting operation shall act in accordance with the relevant laws of the requesting Party. The appropriate authorities of the requesting Party shall cooperate with the authority designated by the assisting Party, pursuant to Article 17, as being in charge of the immediate operational supervision of the personnel and the equipment provided by the assisting Party.
2. The requesting Party shall, to the extent of its capabilities, provide local facilities and services for the proper and effective administration of the assistance, and shall ensure the protection of personnel, equipment and materials brought into its territory by, or on behalf of, the assisting Party for such a purpose.
3. Unless otherwise agreed by the Parties concerned, assistance shall be provided at the expense of the requesting Party. The assisting Party may at any time waive wholly or partly the reimbursement of costs.
4. The requesting Party shall use its best efforts to afford to the assisting Party and persons acting on its behalf the privileges, immunities or facilities necessary for the expeditious performance of their assistance functions. The requesting Party shall not be required to apply this provision to

its own nationals or permanent residents or to afford them the privileges and immunities referred to above.

5. A Party shall, at the request of the requesting or assisting Party, endeavor to facilitate the transit through its territory of duly notified personnel, equipment and property involved in the assistance to and from the requesting Party.
6. The requesting Party shall facilitate the entry into, stay in and departure from its national territory of duly notified personnel and of equipment and property involved in the assistance.
7. With regard to acts resulting directly from the assistance provided, the requesting Party shall, in respect of the death of or injury to persons, damage to or loss of property, or damage to the environment caused within its territory in the course of the provision of the assistance requested, hold harmless and indemnify the assisting Party or persons acting on its behalf and compensate them for death or injury suffered by them and for loss of or damage to equipment or other property involved in the assistance. The requesting Party shall be responsible for dealing with claims brought by third parties against the assisting Party or persons acting on its behalf.
8. The Parties concerned shall cooperate closely in order to facilitate the settlement of legal proceedings and claims which could result from assistance operations.
9. Any Party may request assistance relating to the medical treatment or the temporary relocation in the territory of another Party of persons involved in an accident.
10. The affected or requesting Party may at any time, after appropriate consultations and by notification, request the termination of assistance received or provided under this Convention. Once such a request has been made, the Parties concerned shall consult one another with a view to making arrangements for the proper termination of the assistance.

Nevertheless some aspects seem to hamper their implementation. These aspects may be the accountability of the assistance requesting country for the costs of assistance, the lack of capacities for coordination of international assistance in requesting countries especially in case of Natechs, and the different approaches to respond to chemical accidents.

Issues requiring further discussion

1. How to improve the international co-operation in Natech prevention, preparedness and response?
2. Which role should play the OECD in that context?
3. Are there gaps/shortcomings in the international emergency assistance for Natechs?
4. Are there shortcomings in the application of the PPP in case of international assistance?
5. Which support in international assistance could offer the private sector (e.g. as a part of Responsible Care)?

Annexe: Background Information

Introduction

Consideration of Natechs in the OECD Recommendations and Guiding Principles

The OECD Recommendation of the Council concerning Chemical Accident Prevention, Preparedness and Response 15 January 2004 - C(2003)221 recommends that Member countries establish or strengthen national programmes for the prevention of, preparedness for, and response to accidents involving hazardous substances. In undertaking the activities, Member countries take into account the second edition of the OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response[16].

The Guiding Principles also apply to chemical accidents that occur as a result of the impact of natural hazards.

As explained in the "Notes to Golden Rules", page 25 (emphasis added):

- Accidents **are defined to include unexpected events that could be triggered by**, for example, technological or human error, deliberate acts (such as sabotage, terrorism, vandalism or theft) or **natural disasters**.

The role of industry with respect to "know the hazards and risks at installations where there are hazardous substances" is described in the "Golden Rules", page 21 (emphasis added):

- Hazard identification and risk assessments should be undertaken from the earliest stages of design and construction, throughout operation and maintenance, and should address the possibilities of human or technological failures, as well as releases resulting from **natural disasters** or deliberate acts (such as terrorism, sabotage, vandalism or theft). Such assessments should be repeated periodically and whenever there are significant modifications to the installation.

The role of industry with respect to hazard identification and risk assessment is detailed in Chapter 2, section 2.b.6 of the Guiding Principles, page 39 (emphasis added):

- Accident scenarios considered as part of the risk assessment process should take into account the possibility of human and technological errors, as well as **the possibility of natural disasters** and/or deliberate acts (e.g., sabotage, terrorism, vandalism or theft) triggering a chemical accident.

National Legal Requirements Concerning Natechs

In the EU, chemical hazardous installations that have a major-accident potential are regulated by the Seveso II Directive on the control of major-accident hazards (96/82/EC)[17] and its amendment (2003/105/EC)[18]. Due to the type and quantity of hazardous materials normally processed or stored in these installations, the Directive requires stringent standard protection measures to be implemented. A recent proposal for a revision of the Directive makes Natech risk more explicit by requiring that environ-

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16 Published by OECD on the responsibility of the Secretary General as Environment, Health and Safety Publication, Series on Chemical Accidents, No. 10

17 Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances, OJ L 10, 14.1.1997, p. 13–33

18 Directive 2003/105/EC of the European Parliament and of the Council of 16 December 2003 amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances, OJ L 345, 31.12.2003, p. 97–105

mental risks and hazards must be considered in the safety report. As examples earthquakes and floods are mentioned[19].

In Japan, chemical-accident prevention and safety management is regulated by various laws including the High Pressure Gas Safety (HPGS) Law, the Fire Defence (FD) Law, and the Law for Prevention of Disasters at Petroleum Complexes (PDPC), among others. None of these laws specifically requires carrying out a risk assessment for potential chemical accidents with off-site consequences (Matsumoto 2005). However, damage incurred by petroleum refineries during past earthquakes has prompted the adoption of a broad range of earthquake hazard-reduction measures. The PDPC, for example, stipulates detailed restrictions concerning the layout of processing facilities in order to maintain the safety of people and property in a petrochemical industrial zone. The law may require the setting aside of passageways of six to twelve meters, and set-back areas of three to five meters for use by fire-fighters. In addition, the PDPC law requires the establishment of united collective hazard-mitigation and emergency-response systems to prevent disasters in oil and chemical complexes.

In the United States there are several federal programs in place for hazardous-materials risk management and emergency-response planning including the Process Safety Management (PSM) regulation and Risk Management Planning (RMP) rule. In response to these requirements, industrial facilities, in addition to carrying out a process-safety analysis, need to maintain process-safety information, evaluate existing mitigation measures and standard operating procedures, and develop training and maintenance programs. An emergency-response program is also required which should include measures taken to protect human health and the environment in response to an accidental hazardous-materials release and establishing procedures for notifying the public and local agencies. However, none of the US Federal regulations requires analysing, preparing for, or mitigating releases, which are concurrent with natural disasters. Furthermore, there are no specific provisions in the PSM or the RMP to prevent "domino effects" which occur more frequently during earthquakes or for land use planning. Due to the high risk of earthquakes in California, the California Accidental Release Prevention (CalARP) Program calls specifically for a risk assessment of potential releases due to an earthquake and the adoption of appropriate prevention and mitigation measures to prevent earthquake-triggered hazardous-materials releases.[20]

Summarizing the analysis of the legal requirements in most of the countries accidents triggered by extreme events must not be considered by the relevant plant managers. So maps which illustrate the endangered area caused by different natural hazards do not generally consider extreme events.

Relevant Natural Hazards

There are a lot of damages of industrial plants due to natural hazards were caused by floods and earthquakes. So this both hazards shall be considered in detail.

Figure 2 illustrates the relevant natural hazards all over the world.

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19 Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on control of major-accident hazards involving dangerous substances, COM/2010/0781 final - COD 2010/0377, 21.12.2010 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0781:FIN:EN:PDF

20 Cruz, A.M.; Okada, N.: Consideration of natural hazards in the design and risk management of industrial facilities. Natural Hazards 2007

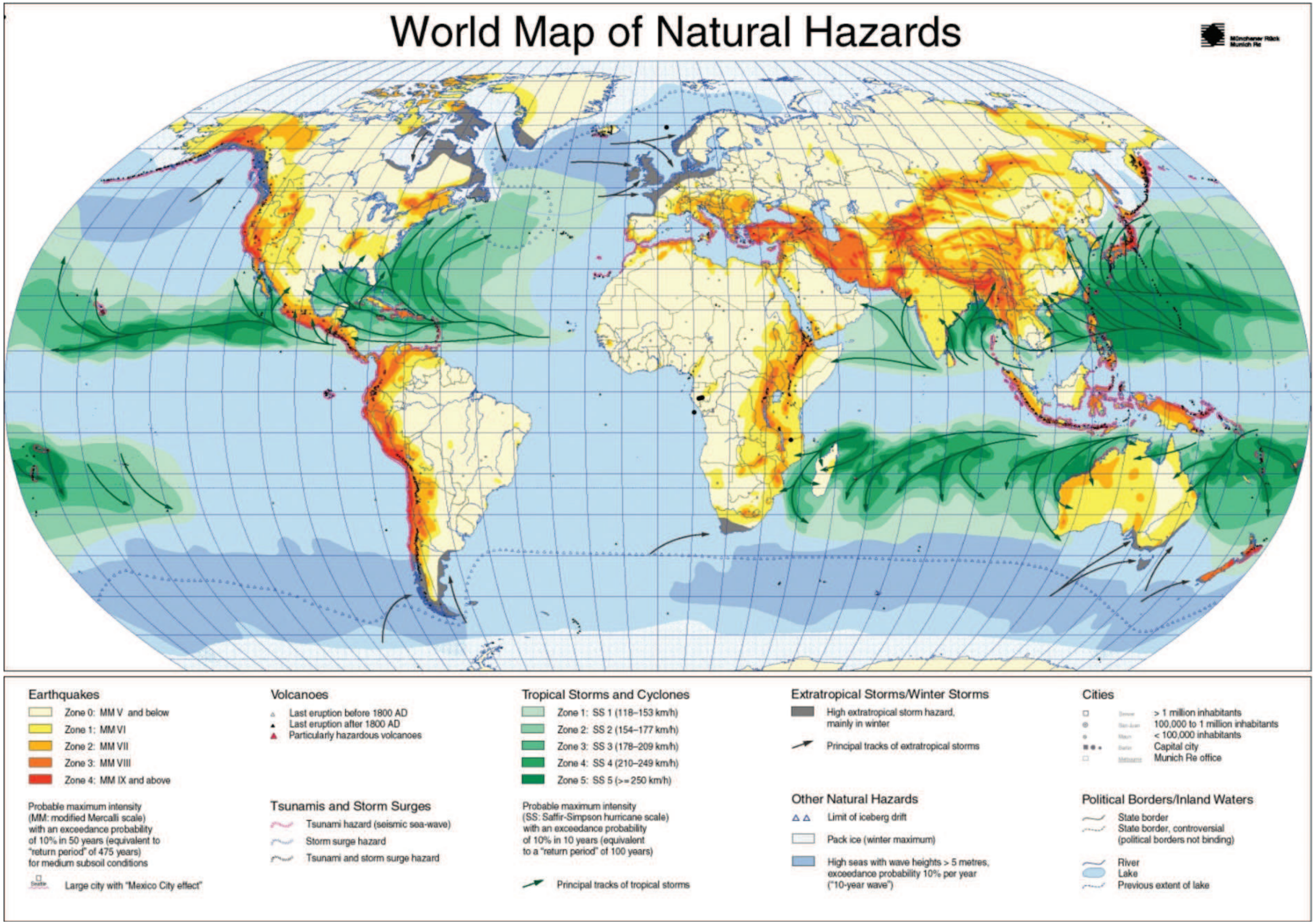

Figure 2: *munichre: World Map of Natural Hazards*

Session I. Hazard and Risk Mapping and Warning Systems

Hazard and Risk mapping

Introduction

Hazard Mapping and Risk Assessment are essential to the establishment of a Comprehensive Risk Management Program. Hazard mapping provides input to educational programs to illustrate local hazards, to scientists studying hazard phenomena, land use planners seeking to base settlement locations to reduce hazard impacts and to combine with other information to illustrate community risks.

As examples the following hazard maps have been elaborated in different countries:

- Flood maps
- Landslide maps
- Earthquake maps
- Liquefaction susceptibility maps
- Wind and storm maps
- Rainfall maps
- Snow load maps
- Avalanche maps

In most of the countries the maps base on statistical calculations of natural hazard events in the past. They illustrate the endangered areas and depending on the kind of the map and hazard additional information are given such as intensity (earthquake), water depth or velocity (flood).

Hazard and risk mapping is in the first instance a national assignment supported by experts of different institutions.[21] The national authorities have to appoint the requirements for hazard and risk mapping.

Because these maps have been made primarily prepared as a basis for the works of the authorities, e.g. land-use planning and risk management programs, natural extreme events which must be considered for the assessment of plant safety are mostly disregarded.

An example of best practice for hazard maps supply and dissemination is the Federal Office for the Environment (FOEN) of Switzerland. FOEN provided a map with all locations of possible emissions of chemicals. This map can be mixed with the different natural hazards maps (e.g earthquakes and/or flood) but also with maps of historical events. To each historical event special information is provided in this interactive system.

Furthermore, the time of return for flood can by varied between 50 years and 500 years. The scale can be adjusted by the user to receive exact information with high resolution about potential natural hazards in the regarded location.

[21] Noson, L.: Hazard Mapping and risk Assessment. Regional Workshop on Best Practices in Disaster Mitigation

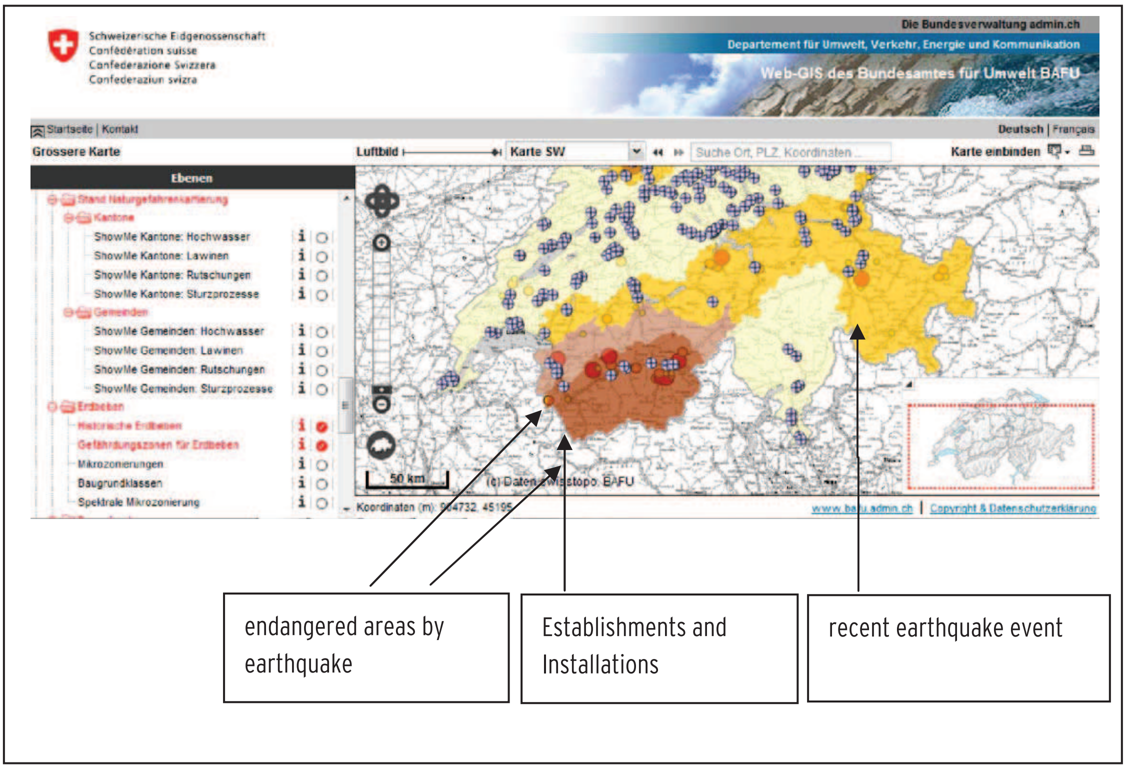

Figure 3: *Internetportal of the Federal Office for the Environment of Switzerland*

European Flood Directive

As an example of consideration of extreme flood event in flood risk maps the European Flood Directive (EFD)[22] of September 2007 is presented and discussed in the following.

The following three kinds of maps are required by the directive:

- A preliminary flood risk assessment: the aim of this step is to evaluate the level of flood risk in each river basin district or unit of management and to select those areas on which to undertake flood mapping and flood risk management plans. This had to be completed by 2011.
- Flood mapping comprising of flood hazard maps and flood risk maps: the flood hazard maps should cover the geographical areas which could be flooded according to different scenarios; the flood risk maps shall show the potential adverse consequences associated with floods under those scenarios. This has to be completed by 2013.
- Flood risk management plans: on the basis of the previous maps, the flood risk management plans shall indicate the objectives of the flood risk management in the concerned areas, and the measures that aim to achieve these objectives. This has to be completed by 2015.

This directive asks the Member states to implement flood mapping according to some minimum recommendations. These are outlined in Article 6.3 and 6.4 of the directive:

"Flood hazard maps shall cover the geographical areas which could be flooded according to the following scenarios:

a) floods with a low probability, or extreme event scenarios;

b) floods with a medium probability (likely return period ≥ 100 years);

c) floods with a high probability, where appropriate.

For each scenario referred to in paragraph 3 the following elements shall be shown:

[22] EXCIMAP, European exchange circle on flood mapping : Handbook on good practice for flood mapping in Europe, 29-30 November 2007

a) the flood extent;

b) water depths or water level, as appropriate;

c) where appropriate, the flow velocity or the relevant water flow."

and Article 6.5:

"Flood risk maps shall show the potential adverse consequences associated with flood scenarios referred to in paragraph 3 and expressed in terms of the following:

a) the indicative number of inhabitants potentially affected;

b) type of economic activity of the area potentially affected;

c) installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;

d) other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution."

The EU-directive does not define the meaning of extreme event scenarios, so all member states are free to establish their own definition or requirements. Such a scenario can be the strongest hazard event in history in the considered area or events with different return period of >100, 500 or more years depending on the kind of hazard and the location.

Early Warning Systems

In 2006, the United Nations released its ~~*Global Survey of Early Warning Systems*~~ which identified four elements in natural hazard early warning systems:[23]

1. Risk Knowledge – systematic assessment of hazards and vulnerabilities, and mapping of their patterns and trends.
2. Monitoring & Warning Service – accurate and timely forecasting of hazards using reliable, scientific methods and technologies.
3. Dissemination & Communication – clear and timely distribution of warnings to all those at risk.
4. Response Capability – national and local capacities and knowledge to act correctly when warnings are communicated.

In the following chapters some early warning systems for earthquake, tsunami, extreme weather and flood are presented.

Earthquake Warning Systems

Targets of Earthquake Predictions

Earthquake prediction can be a measure to mitigate the risks of industry damages. But the term "earthquake prediction" is often used to describe two different usages:

1. prediction of the seismic activities in a region. This is a more scientific prediction of a physical system. In fact it is a study of physics of earthquakes. This kind of prediction is called "long-term forecast" and has important social implications on time scales of month and years.

[23] United Nations: Global Survey of Early Warning Systems, Sept. 2006

2. prediction of an earthquake with a specified time window (hours or days), space window, specified magnitude window. This kind of prediction ought to be exact as possible by minimizing the assessment failure. These requirements refer to the so-called "short-term prediction".

An earthquake is a sudden fracture in the Earth`s interior, together with the resulting ground shaking. It is a long-term complex stress accumulation and release process occurring in a highly heterogeneous medium. Advances have been made in understanding crustal deformation and stress accumulation processes, rupture dynamics, rupture patterns, frictions and constitutive relations, interactions between faults, fault-zone structures, and non-linear dynamics. However, the incompleteness of understanding of the physics of earthquakes in conjunction with the obvious difficulty in making detailed measurements of various field variables (structure, strain etc.) in the Earth makes accurate deterministic short-term predictions difficult.

Due to these uncertainties a strategy for seismic hazard mitigation was developed during the last decades. The usefulness of forecasts depends on different time scales involved for such assessments.[24]

- On the time scale of decades, land use regulations and building codes need to be improved. (Regional seismic hazard assessment)
- On the time scale of few years, earthquake preparedness measures should be encouraged at personal and community levels. (Intermediate-term strategy)
- On shorter time scales, month to days, accurate earthquake predictions of size, location, and time would be required. (Short-term or real-time strategy)

Regional Seismic Hazard Assessment

The long-term seismic hazard is usually expressed in maps illustrating the likelihood of earthquake occurrence or of specific parameters such as the probability of exceedence of given levels of ground shaking over a certain period (e.g. 30 years). In some cases, the hazard value is time-dependent in the sense that it depends on the time since the last large earthquake in the region. In other cases, the hazard value is estimated on the basis of integrated geological data and seismological data for a region, and is time-independent in the sense that it does not change with the time from some specific earthquakes in the region. This type of long-term hazard estimate is important for various seismic hazard reduction measures such as the development of realistic building codes, retrofitting existing structures, and land-use planning.

The distinction between hazard (the physical phenomenon such as ground shanking) and risk (the likelihood of human and property loss) needs to be communicated to the plant designers and operators.

Intermediate-Term Strategy

Although short-term prediction with high probability of success is not possible at present, not in the foreseeable future, there is a possibility that improved physical measurements of various parameter of the crust can be used to identify the areas where the state of the crust is close to failure. For example, continuous monitoring of strain changes in the Earth's crust with GPS will provide the experts with critical information on where strain is accumulating rapidly and where a seismic deformation is taking place.

Other parameters like electromagnetic properties, changes of discharge rate and chemistry of groundwater, radon emissions etc. could provide important information on future earthquake activities. However, it is important to note that the investigations of these phenomena should be considered exploratory at present, and overly optimistic statements on the usefulness of these studies for operational earthquake predictions should be avoided.

[24] H. Kanamori: Earthquake Prediction: An Overview. International Handbook of earthquake and engineering seismology, Vol. 81B, 2003

Short-Term / Real-Time Strategy

To minimize the immediate impact of large earthquakes, a mitigation strategy using real-time technology has been implemented. Real-time strategy is based on the following three steps illustrated in **Figure 4**.

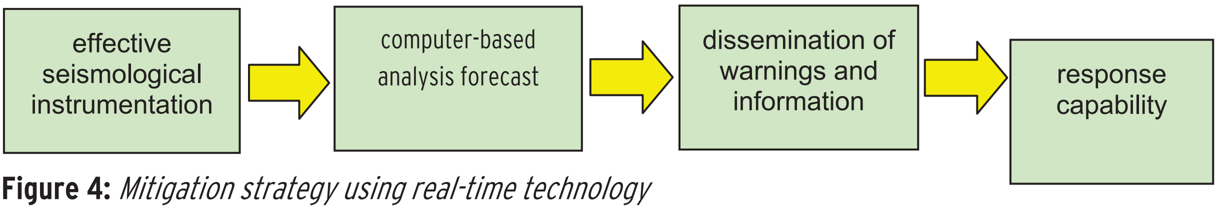

Figure 4: *Mitigation strategy using real-time technology*

Some facilities could receive this information before ground shaking begins. This would allow for clean emergency shutdown or other protection of systems susceptible to damage, such as power stations, computer systems, and telecommunication networks. The idea of using rapid earthquake information is not new and several systems have been developed for example in Japan, Mexico, Taiwan, and the United States. The systems in Mexico and Japan are shortly presented in the following.

Geophysical basics

The basis of most of the systems is the measurement of the so-called P- and S-waves. Primary waves (P-waves) are compression waves that are longitudinal in nature. P waves are pressure waves that travel faster than other waves through the earth to arrive at seismograph stations first hence the name "Primary". These waves can travel through any type of material, including fluids, and can travel at nearly twice the speed of S waves. Secondary waves (S-waves) are shear waves that are transverse in nature. These waves arrive at seismograph stations after the faster moving P waves during an earthquake and displace the ground perpendicular to the direction of propagation. When reaching seismic observatories, their different velocities help scientists to locate the source of the earthquake hypocentre.

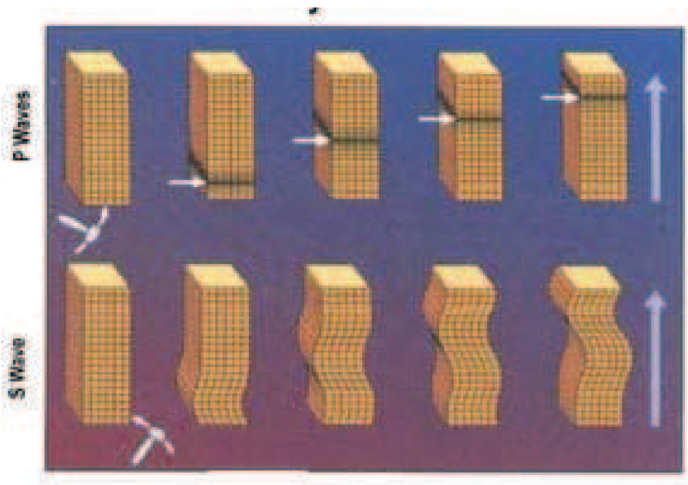

Figure 5: *Illustration of body waves*

Forecast System in Mexico

In 1985, a M = 8,1 (M = Magnitude) earthquake in the Michoacan seismic gap, about 320 km west of Mexico City, caused very heavy damage in Mexico City. Because a similar large earthquake is expected within the next few decades in the Guerrero seismic gap, about 300 km southwest of Mexico City a seismic alert system (SAS) was developed as a public early warning system in 1991. This system has a specific objective: to detect M > 6 earthquakes in the Guerrero gap with a seismic network deployed in the gab area, and issue an early warning of strong ground motion to the residents and authorities in Mexico City. The system consists of 15 accelerometers located along the coast of the State of Guerrero, above a segment of subduction plate boundary that is a mature seismic gap. An algorithm estimates the magnitudes of earthquakes from the near-source accelerograms and issues public and restricted alerts for earthquakes with *M* ‡6 and 5 ‡ *M* < 6, respectively. Because it takes 100 sec for seismic waves to travel from Guerrero area to Mexico City, this system could provide an early warning with up to 60 sec lead time. A M = 7,3 earthquake occurred on September 14, 1995, in the Guerrero gap, and this system successfully broadcast an alarm on commercial radio stations in Mexico City about 72 sec prior to the arrival of strong ground motion.[25]

In spite of this impressive success an evaluation of the SAS's performance during 1991–2004 reveals a surprisingly high rate of failure and false alerts.[26] This poor performance results from an inadequate detection algorithm and a limited areal coverage by the SAS.

The most notorious deficiency of the SAS is not the technical operation and performance. The most evident and important shortfall is the very limited number of registered users.[27] After almost 18 years (2009) of operation the SAS has only 230 registered users; 25 are radio and television broadcasting stations, 76 are schools, 12 are emergency and civil protection agencies, four are offices of the subway system, 79 are government offices, 33 are private institutions, and only one is a residential building. In this list no industrial user is mentioned.

Forecast System in Japan

In the cases that major earthquake location is clear and far from cities, the SAS system can be comparatively easily effective, like in Mexico. In Japan, however, any places have potentials of the large earthquake occurrence and there are many cities with various distances from the earthquake source areas. So a system is necessary that can pick accurate arrival time of seismic phases, and determine hypocentre and magnitude with a few station data, to broadcast earthquake early warning practically. A system is developed, which automatically determines hypocentre and magnitude very quickly, and provides an earthquake early warning just a few seconds (almost less than 5 to 6 seconds) after P-wave arrival at the nearest station to a hypocentre.[28]

A wide and dense seismic network with real-time telemetry is necessary to use this method effectively. After the 1995 Kobe earthquake National Research Institute for Earth Science and Disaster Prevention (NIED) have established a highly sensitive and dense seismic network in Japan, named Hi-net. The network uses three-component velocity seismometers in boreholes deeper than 100 m (the deepest one has depth of 3000 m), and sends waveform data to the NIED data centre via frame-relay telemetry. The telemetry delay is almost shorter than 2 seconds for 95% of the data packets. As the result, Japan has a dense and uniform seismic network with real-time telemetry for almost all of Japan (**Figure 6**). The establishment of this seismic network makes the earthquake early warning system possible in Japan.

[25] Espinosa-Aranda, J.M. et al.: Mexico City Seismic Alert System. Seismol. Res. Letters 66, 42-53, 1995

[26] A. Iglesias, S. K. Singh, M. Ordaz, M. A. Santoyo, J. Pacheco: The Seismic Alert System for Mexico City: An Evaluation of Its Performance and a Strategy for Its Improvement. Bulletin of the Seismological Society of America, 2007

[27] Espinosa-Aranda, J.M. et al.: Evolution of the Mexican Seismic Alert System (SASMEX). Seismological Research Letters, Vol. 80, 5, Sep./Oct. 2009

[28] H. Negishi and S. Yamamoto: EARTHQUAKE EARLY WARNING SYSTEM AT A LOCAL GOVERNMENT AND A PRIVATE COMPANY IN JAPAN. First European Conference on Earthquake Engineering and Seismology, Geneva, Switzerland, 3-8 September 2006 Paper Number: 741

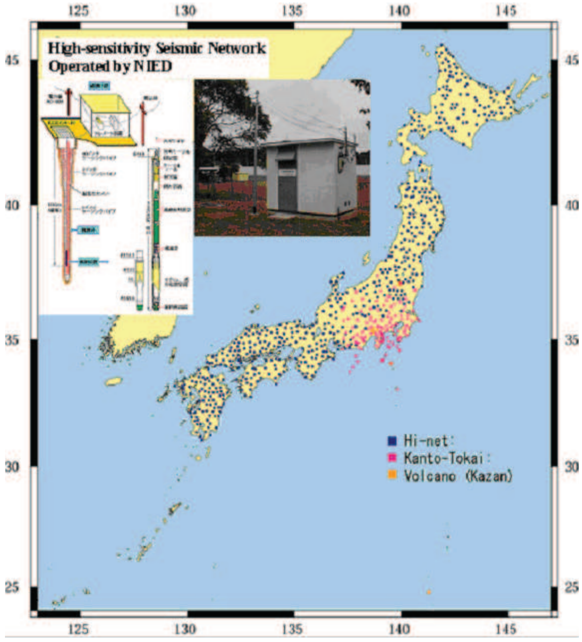

Figure 6: *High-sensitivity Seismic Network Operated by NIED in Japan*[29]

Forecast System in the Istanbul Region

As part of the preparations for the future earthquake in Istanbul a Rapid Response and Early Warning system in the metropolitan area is in operation.

The Istanbul Earthquake Rapid Response System equipped with 100 instruments and two data processing centres aims at the near real time estimation of earthquake damages using most recently developed methodologies and up-to-date structural and demographic inventories of Istanbul city. After the transmission of ground motion parameters by the field stations, shake and building damage distribution maps, using spectral displacement based fragility relationships, are automatically generated and transmitted to emergency operation centres within 3 minutes using radio modem and GSM communication. The system has so far exposed to several small magnitude (ML=3-4) earthquakes and performed satisfactorily. The methodology developed for near real time estimation of losses after a major earthquake consists of the following general steps: (1) rapid estimation of the ground motion distribution using the strong ground motion data gathered from the instruments; (2) improvement of the ground motion estimations as earthquake parameters become available and (3) estimation of building damage and casualties based on estimated ground motions and intensities.

For the Early Warning system ten strong motion stations were installed as close as possible to the fault zone to transmit on-line data via digital radio modem and satellite telemetry. A simple and robust Early Warning algorithm, based on the votes of exceedance of specific filtered acceleration and cumulative absolute velocity (CAV) levels are implemented. The users of the early warning signal are power and gas companies, nuclear research facilities, critical chemical factories, subway system and several high-rise buildings.

29 H. Negishi and S. Yamamoto: EARTHQUAKE EARLY WARNING SYSTEM AT A LOCAL GOVERNMENT AND A PRIVATE COMPANY IN JAPAN. First European Conference on Earthquake Engineering and Seismology, Geneva, Switzerland, 3-8 September 2006 Paper Number: 741

Tsunami Warning Systems

During the last years tsunami warning systems have been established all over the world. They can be distinguished between international warning systems and regional warning systems.

International Warning Systems

Pacific Ocean:	Pacific Tsunami Warning Center (PTWC), operated by the United States NOAA in Ewa Beach, Hawaii. NOAA's West Coast and Alaska Tsunami Warning Center (WCATWC) in Palmer, Alaska International coordination is achieved through the International Coordination Group for the Tsunami Warning System in the Pacific, established by the Intergovernmental Oceanographic Commission of UNESCO.
Indian Ocean:	A United Nations conference was held in January 2005 in (ICG/IOTWS) Kobe, Japan, and decided that as an initial step towards an International Early Warning Programme, the UN should establish an Indian Ocean Tsunami Warning System. This then resulted in a system of warnings in Indonesia.
North Eastern Atlantic, the Mediterranean connected Seas:	The First United Session of the Inter-governmental Coordination Group the Tsunami Early Warning and Mitigation System and for in the North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS), established by the Intergovernmental Oceanographic Commission of UNESCO.
Caribbean:	A Caribbean-wide tsunami warning system has been planned to be instituted by the year 2010, by member nations representatives who met in Panama City in March 2008.

Regional Warning Systems

Regional (or local) warning system centres use seismic data about nearby recent earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable of issuing warnings to the general public (via public address systems and sirens) in less than 15 minutes. Although the epicenter and moment magnitude of an underwater quake and the probable tsunami arrival times can be quickly calculated, it is almost always impossible to know whether underwater ground shifts have occurred which will result in tsunami waves. As a result, false alarms can occur with these systems, but the disruption is small, which makes sense due to the highly localised nature of these extremely quick warnings, in combination with how difficult it would be for a false alarm to affect more than a small area of the system. Real tsunamis would affect more than just a small portion.

As an example of a regional warning system the technical network and the organisation in Japan is presented in figure 5. The transmission of tsunami warnings consists of the main steps observation, analysis forecast and dissemination.[30]

[30] Japan Meteorological Agency: Tsunami Warning System in Japan, March 2006

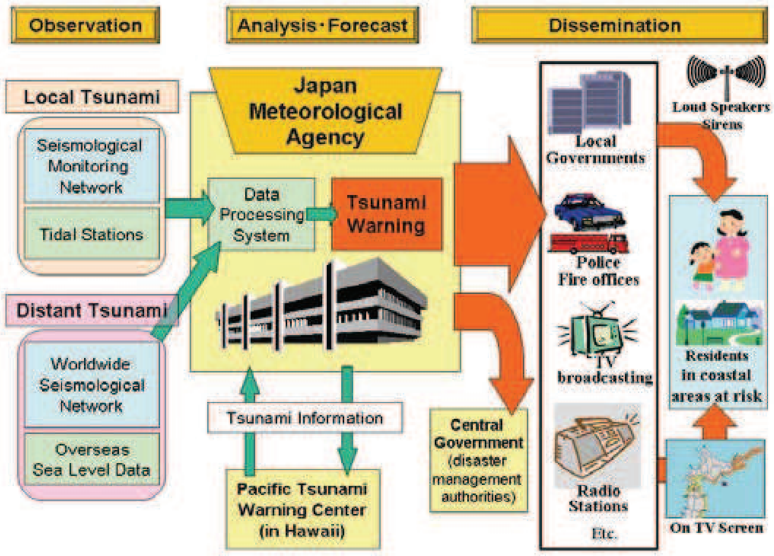

Figure 7: *Transmission of the tsunami warning (Japan Meteorological Agency)*

Observation network of the Japan Meteorological Agency (JMA) consists of about 180 seismic stations. The seismic data are transmitted on a real time basis by the dedicated telephone lines to the JMA headquarters and centres in each district observatory. Transmission lines are connected between neighbouring centres to share the earthquake data. This network allows for continued monitoring and analysing of earthquakes, even if part of the network would be damaged by a large earthquake. By using the seismic network and processing computers, earthquake location and magnitude are determined quickly after detection of the earthquake.

A database of the relationship between earthquake occurrence and tsunami arrival based on about 100,000 cases of computer simulation is prepared for tsunami forecast around Japan (the quantitative tsunami forecast system).

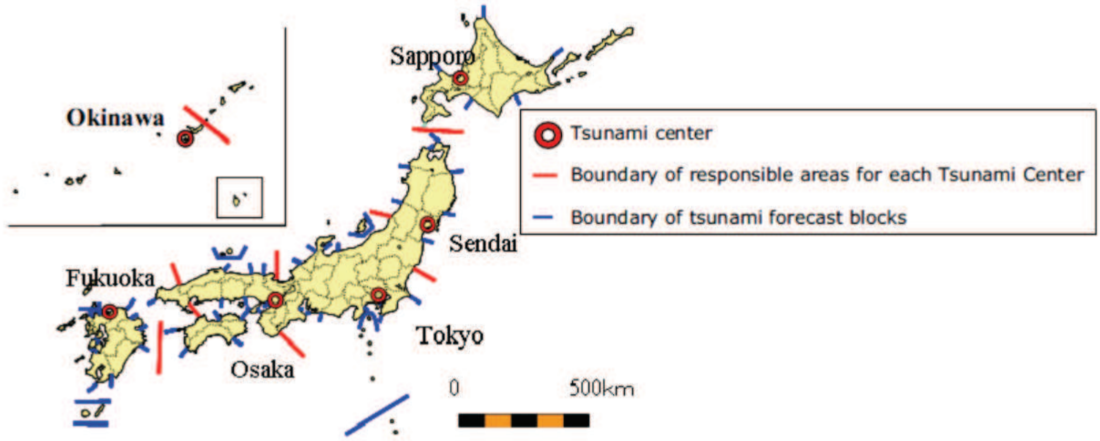

Figure 8: *Tsunami warning centres (Japan Meteorological Agency)*

When a large earthquake occurs, the database is searched using the location and magnitude of the earthquake as indices, and the stored heights and arrival times of tsunami along the coasts are read out, for the issuance of tsunami warning for individual 66 tsunami forecast blocks in the Japanese coastal area.

In case of an earthquake occurrence, JMA analyses the earthquake observational data and quickly issues tsunami warning, if necessary. The warning is automatically transmitted to disaster management authorities and broadcasting media. The earthquake and tsunami information including tsunami warning is used as a trigger of evacuation and urgent operation for rescue and mitigation of disasters.

The earthquake on 11th March 2011 was the worst seen in that country for over 300 years (with a local magnitude of 8.9). Hundreds have been killed and injured so far, but the loss of life was likely limited by two vital early warning technologies: the earthquake alert system, and ocean-based tsunami warning system.

The earthquake warning system, which has never been triggered before, automatically issued alerts via television and cell phones shortly after the first, less harmful, shock wave was detected, providing time for many people to prepare for the more powerful shock wave that followed. It also caused many energy and industrial facilities, and transportation services to shut down automatically. A string of detection buoys in the Pacific Ocean detected the tsunami that resulted from the earthquake, sending warnings of possible catastrophe to many different nations.

Local Warning System for Extreme Weather [31]

In the past years, damages caused by severe weather conditions have increased dramatically and scientists expect this trend to continue due to climate changes induced by greenhouse gas emissions.

One example is the German project SAFE. The SAFE project, funded by the German Federal Ministry of Education and Research (BMBF), aims at protecting the public against such threats. Its goal is to develop an integrated platform which combines distributed weather sensor networks with improved, location-specific weather prognosis modules and an early warning messaging system. This messaging system is used to provide both the general public and emergency services with personalized, situation-dependent information on upcoming extreme weather conditions.

Furthermore, SAFE is able to steer remote-controlled actuators that induce automated countermeasures, such as closing open windows, retracting blinds, or disconnecting sensitive electronic equipment from the power grid.

The core component of the SAFE project is an information logistics platform, which – in accordance with predefined disaster prevention procedures – generates personalized disaster warning messages and distributes these to system subscribers. In a first step, weather data from global forecasting models is combined with localized weather information (e.g., gathered by weather radar) and translated into location-specific weather prognoses.

Prognoses can be generated for all relevant natural areas in Germany (roughly 1,000 such areas are considered). For each of these areas, warning levels are defined and constantly updated. Warning messages for subscribers are generated by comparing the subscribers' location and their warning request profiles with actual warnings issued by the meteorological component. Messages are then delivered through the preferred communication media, which are specified by subscribers through an online interface.

Messaging alternatives implemented so far allow for distribution via e-Mail, SMS, RSS feed, and through TV set-top boxes. The implemented solution was optimized with respect to high-throughput capabilities and the system has already proven these by distributing 13,107 SMS within 2:28 minutes to warn subscribers of an approaching hailstorm in the Vienna area.

Flood Warning Systems

Flood protection of industrial plants includes flood provision, technical protection and flood management illustrated as three columns in **figure 9**.

31 Klafft, M.; et al.: SAFE: A Sensor-Actuator-based Early-warning System for Extreme Weather Situations, 2008

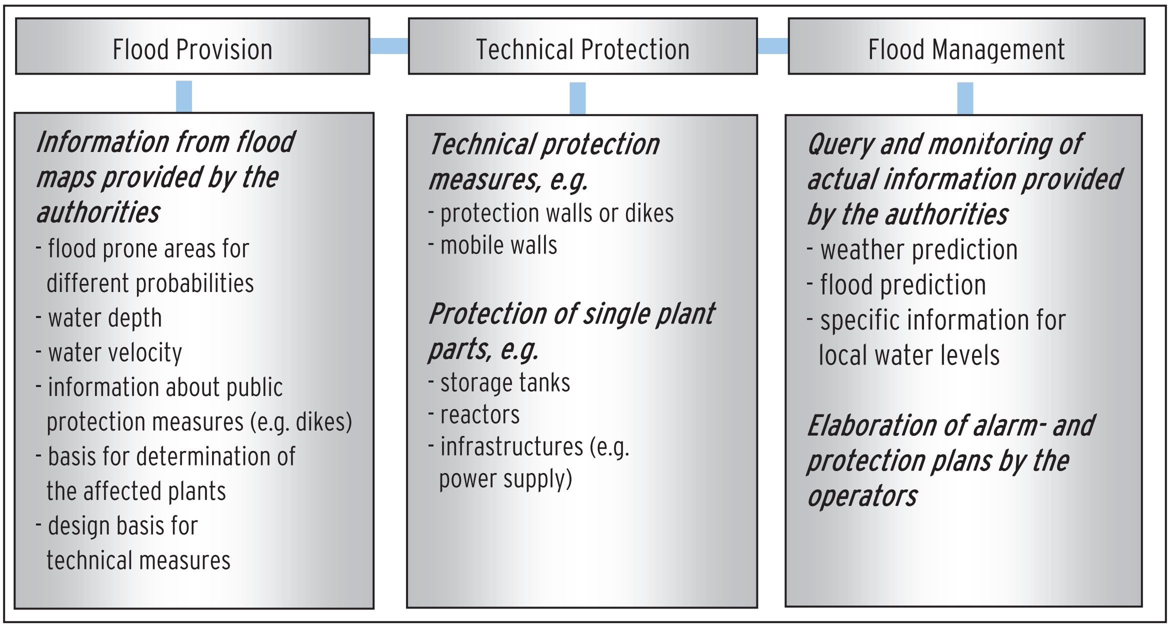

Figure 9: *Structure of internal flood risk management*[32]

Figure 9 shows that flood warning systems consists of 2 elements:

- Flood hazard maps (long-term forecast) according column 1
- Actual information about weather prediction and flood risk (short-term prediction) according column 3

Flood maps exist in many different forms, but in general it is possible to distinguish between flood hazard and flood risk maps. While flood hazard maps contain information on the probability and/or magnitude of a flood event, flood risk maps depict additional information about their consequences (e.g. economic damage, number of victims, etc.). Various parameters can be used to denote the flood hazard, such as flood extent, water depth, flow velocity, duration and the rate at which the water rises. Out of these parameters, water depth is one of the main factors of importance with respect to flood damage (and consequently flood risk). In their study on flood maps in Europe, de Moel et al. show that flood extent maps are the most common type of flood maps, followed by historical flood maps and water depth maps.[33] The use of flood risk maps is less common, but useful in the insurance economy.

If flood hazard maps are distributed efficiently, they can greatly enrich the knowledge about flood hazards. The information contained in flood hazard maps enables all stakeholders and plant managers to make decisions for construction planning, building protection, action plans and other precautionary measures.

Today, dynamic and interactive maps on the web are more popular than ever. Different experts believe that the dissemination of flood maps via the internet can form an important way of bringing flood information to the public and private users.[34] When combined with real-time data on water levels and precipitation, web flood maps can hold information of vital importance to plant managers and inhabitants in flood prone areas.

[32] Warm, H.-J.; Köppke, K.-E.: Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Safety of new and existing facilities and establishments against natural environmental hazards, especially floods). German Federal Environmental Agency, 2007 Ref.No.: 203 48 362

[33] de Moel, H. et al.: Flood maps in Europe - methods, availability and use. *Natural Hazards and Earth System Sciences,* 9, 289-301, 2009

[34] Hagemeier-Klose, M.; Wagner, K.: Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication. *Natural Hazards and Earth System Sciences,* 9, 563-574, 2009

Flood maps exist in two forms on the internet: static and dynamic. While static web maps are fixed (no user adaptations possible), dynamic web maps are adjustable to the user's preferences. Static web maps are highly similar to printed maps, and should therefore follow the same cartographic principles. Because of their interactivity and adjustability, more freedom exists in dynamic web maps. It's up to the user to decide which information is to be shown on the map.

More and more 3D-maps and animations are in use for special areas in order to illustrate the flood hazard (**Figure 10**)[35]

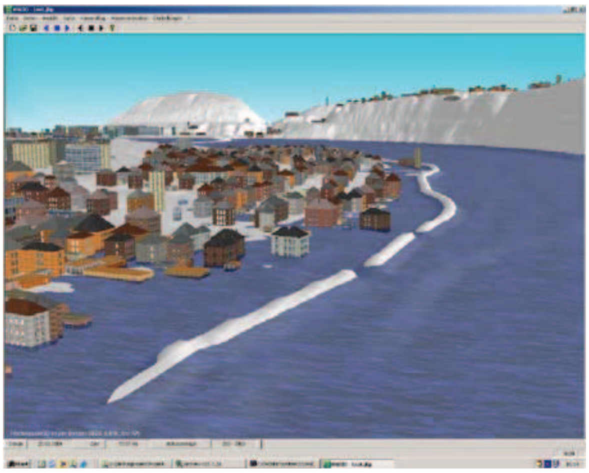

Figure 10: *3D-animation*[36]

Types of Floods

The following types of floods can be distinguished:

Riverine Flood: This type of flood occurs after prolonged precipitation over large areas of the basin. Melting snow can also exceed the capacity of river channels; hence leading to flooding. Normally river floods last for two or three several days (2-3 days) to two weeks and usually affect large areas.

Coastal Flood: The sea level rise can lead to the gradual encroachment of the sea. Along the coastal, areas are inundated as a result of tropical cyclone, perigean spring tides, storm surges, their combination, and tsunamis. Some coastal areas are highly vulnerable to cyclone or hurricanes.

Flash Floods: Usually it is occurred due to local precipitations of extreme intensity. This kind of flood occurs in limited area with high flow rate. Flash flood can occur almost anywhere but are particular dangerous on steep slopes.

Urban Flooding: Extreme local rainfall combined with blocked drainage may cause inundations. This type of flood depends on topographical and soil conditions and the existence of drainage systems and mainly occur in flat and low lying areas.

[35] Warm, H.-J.; Köppke, K.-E.: Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Safety of new and existing facilities and establishments against natural environmental hazards, especially floods). German Federal Environment Agency, 2007, Ref.-No. 203 48 362

[36] Warm, H.-J.; Köppke, K.-E.: Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Safety of new and existing facilities and establishments against natural environmental hazards, especially floods). German Federal Environment Agency, 2007, Ref.-No. 203 48 362

On a global scale flood are mainly caused by heavy or long lasting rainfall (approximately 65%), brief torrential rain (15%), tropical cyclone (10%) and monsoon rain (5%), dam break or release (1%), rain & snow melt (3%) and other (1%).[37]

This contribution differs all over the world. In Asia for example flood is mainly caused by heavy rain (55%), torrential rain (15%), tropical cyclones (10%), monsoon rain (15%), dam break/release (2%), rain & snow melt (∻ 1%) & others (3%).

Riverine Flood Warning Systems

Early Warning Systems requires developments in a number of technologies and areas of expertise:

- Sensor equipment in selected local measurement points
- Data transmission
- Middleware for connecting sensor data, relevant documents, analysis tools and modelling software
- Computational models and simulation components for simulation of possible flood dynamics
- Advanced interactive visualization technologies;
- Development of a decision support system that will assist public authorities and plant managers
- Internet-based or dedicated remote access to the early warning and decision support systems.

Dedicated systems to monitor and forecast river basin floods are well established in developed countries, where they are operated by a variety of technical organisations.

However, such systems are much less widespread in developing countries particularly in Africa, Asia and the Caribbean. In many tropical areas, such as in the Indian Ocean Commission (COI) region, flood monitoring and warning systems are closely linked to tropical cyclone warning systems.

Operational global flood forecasts from specialised warning systems provide three-day warnings but several initiatives are underway to extend the warning range. Most flood warning systems are stand-alone national operations, but warning systems have been developed covering several international rivers, such as for the Rhine, Danube, Elbe and Mosel in Europe, the Mekong, Indus and Ganges-Brahmaputra-Meghna basins in Asia and the Zambezi in Southern Africa.[38] Globally, the Dartmouth Flood Observatory in the United States detects, maps, measures and analyses extreme flood events worldwide. The National Oceanographic & Atmospheric Administration (NOAA) in the United States can provide river-flooding guidance six months in advance based on seasonal forecasts and knowledge of major river catchments.

UNESCO and World Meteorological Organization (WMO) currently coordinate an operational flood warning system for river flooding. The International Flood Initiative/Programme (IFI/P), launched during the World Conference on Disaster Reduction in January 2005, is a joint programme of UNESCO and WMO to be operated by the International Centre on Water Hazard and Risk Management (ICHARM), which is hosted by the Public Works Research Institute (PWRI) in Japan. The International Flood Network, through the Global Flood Alert System, provides information on precipitation based on satellite data to global subscribers for free. Such initiatives enhance the services provided by national authorities.

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37 Mir, H.: Urban Floods and an important aspect of the flood mitigation process for reducing the flood damages In Pakistan. http://www.unescap.org/idd/events/2009_EGM-DRR/Pakistan-Hazrat-Mir-paper-final.pdf

38 United Nations: Global Survey of Early Warning Systems, Sept. 2006

The quality of forecast systems depends on the reliability of the results. Forecast reliability in the context of flood forecasts is understood as the probability of correctly predicting a flood event. Forecast reliability is affected by uncertainties inherent to the underlying modelling system and decreases with lead time. Main sources of model predictive uncertainty are uncertainties associated to precipitation forecasts, hydrological model parameters and the model structure. Precipitation forecast uncertainty is quantified by means of ensemble forecasts. Model structure and model parameter uncertainty are strongly interrelated and depend on the event and the location.[39]

A good example of best practice is shown in **figure 9** for the Elbe river basin in Saxonia, Germany with links to the adjacent states and countries. Actual water levels with water flow rate, tendency and warning message.

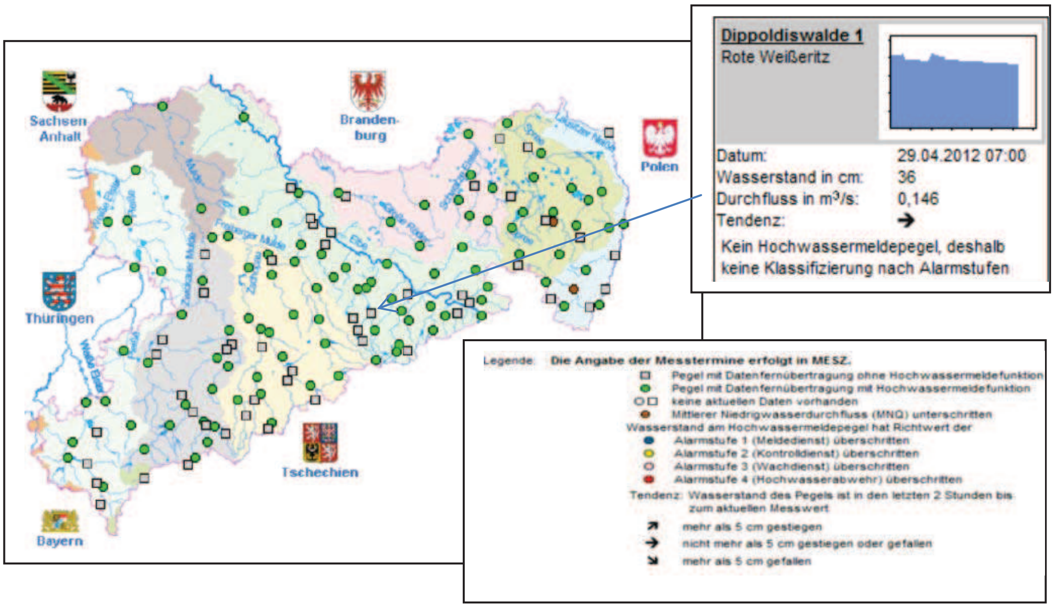

Figure 11: *Forecast system in Saxony, Germany*[40]

Along all rivers measurement points are installed to monitor the water level and flow velocity. All measurement points are fitted with data transmission. Furthermore, selected measurement points are fitted with flood warning function. All users can receive necessary information about the actual situation via an internet platform of the state.

Flashflood Warning Systems

The United Nations study "Global Survey of Early Warning Systems" states, that "some countries monitor flash floods through their National Meteorological and Hydrological Services (NMHSs), while others monitor flash floods and river floods through environmental agencies and hydrology services separately. It is not possible to forecast flash floods but they can be detected as they occur by weather radars if these are present. Most flash floods occur in countries or districts without radar coverage. They are a major killer during tropical cyclone events."

Since 2005 new technologies have been developed. One system will be presented in the frame of this workshop.

Issues Requiring Further Discussion

1. Should data collection, data analysis and dissemination of information about natural hazards be national assignments of the countries and authorities?

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39 Refsgaard, J.C., van der Sluijs, J.P., Brown, J. and van der Keur, P., 2006. A framework for dealing with uncertainty due to model structure error. Advances in Water Resources, 29(11): 1586-1597.

40 Hochwasserzentrale Sachsen: http://www.umwelt.sachsen.de/umwelt/wasser/7806.htm

2. Should requirements for hazard and risk mapping of natural events be required in national legislation?
3. What is best practice in communication of natural hazard maps to operators, communities and public?
4. Should an internationally coordinated guideline be provided for natural hazard mapping?
5. Should - in general - consideration of the different hazard sources be done in cooperation with adjacent countries, e.g. for river basin management activities? (compare EU Water Framework Directive[41] and EU Directive on the assessment and management of flood risks[42])
6. Are special Natech risk maps useful for special cases?
7. Under which conditions makes it sense to recommend early warning systems (e.g. tsunamis)?
8. Which failure rate of alarms and warnings is required to apply these systems successfully in industry?

Predictions of earthquakes are still very uncertain, mainly because the highly complex nature of earthquake process.[43] So the question is, whether these uncertain predictions are useful to prevent Natechs. The benefits of long-term forecast are realistic building codes, retrofitting existing structures, and land-use planning.

Existing short-term forecast could be useful and have shown their success in some cases. But due to uncertainties a high rate of failure and false alarms must be tolerated. The uncertainty of short-term predictions mainly depends on the local earth structures, the density of seismic equipment, the distance between cities or industrial plants and the possible epicenters, and finally the method of the determination algorithms for alarm dissemination. Short-term forecasts are useful in countries where industrial plants are located close to residential areas. In those cases false alarms should be tolerated by the industry.

In order to use the technical measures of short-term forecasting an information program for the industry should be elaborated. The shortfall in Mexico City has shown the necessity of information and cooperation between forecasting systems, authorities and plant safety in case of an earthquake.

Session II: Natech Risk Management

Introduction

One of the principal problems of Natechs is the simultaneous occurrence of a natural disaster and a technological accident, both of which require simultaneous response efforts in a situation in which lifelines needed for disaster mitigation are likely to be unavailable.

In addition, hazardous-materials releases may be triggered from single or multiple sources in one installation or at the same time from several hazardous installations in the natural disaster's impact area.

Krausmann et al.[44] state that "recent studies have indicated that legislation and standards for chemical-accident prevention do not explicitly address Natech risk. In addition, methodologies and tools for the assessment of Natech risk are scarce, and only limited guidance for industry and the authorities on how

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41 Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, 2000

42 Directive 2007/60/EC on the assessment and management of flood risks, 2007

43 Kanamori, H.; Hauksson, E.; Heaton, T.: Real-time seismology and earthquake hazard mitigation. Nature 1997, 390, 461 - 464

44 Krausmann, E; Cozzani, V.; Salzano, E; Renni, E.: Industrial accidents triggered by natural hazards: an emerging risk issue. Nat. Hazards Earth Syst. Sci., 11, 921–929, 2011

to assess Natech risk is available. With climate change predicted to increase the frequency of severe hydro-meteorological events, Natech risk is expected to increase in the future. This highlights the need for the development of tools for industry and authorities to assist in the analysis of the risk in chemical installations and infrastructures due to Natech accidents."

Need of Natech Risk Assessment

A study on the status of Natech risk reduction in OECD Member States was performed by means of a questionnaire survey. The results will be presented by E. Krausmann during the workshop.[45] In spite of some uncertainties in the different answers Krausmann has pointed out that a lot of Natech accidents with the release of toxic substances, fires and/or explosions and sometimes fatalities and injuries had occurred in the member states during the last years, but those accidents were not of major concern for risk assessments. So the author of the study pointed out that there is a discrepancy between actual causes and risk perception.

Although hazard risk reduction exists in the legal requirements of different OECD member states for an effective increase of the protection standard they are not precise enough. This has become evident by the occurrence of Natech accidents. Chemical-accident prevention and pollution-control regulations, such as the Seveso II Directive, do not provide guidance to the operator on how Natech risk reduction should be achieved, nor to the competent authority on how to evaluate that the risk level is as low as required by regulations.

So gaps in legislation, implementation and/or its monitoring that should be addressed to ensure effective Natech risk reduction still exist. In a lot of the responding countries Natech risk is not addressed in natural-disaster management regulations. Existing technical codes and standards for the design, construction and operation of buildings and structures in industry consider certain natural hazards but their ultimate goal is the safety of human life. Therefore, the prevention of hazardous substance releases may not be guaranteed and secondary risks due to these releases may not be taken into account.

Additionally, some of these technical codes and standards may not be suitable for controlling risks due to hazardous substances. Specific guidelines for Natech risk reduction to support legislation are scarce. These results were confirmed in other studies.[46] Therefore, the development of specific technical codes and guidelines would be required to fully address Natech risk.

This highlights the need for the development of guidance, technical rules or tools for industry and authorities to assist in the analysis of the risk in chemical installations and infrastructures due to Natech accidents.[47] The acuteness becomes greater with the predicted climate change. It has to be assumed that the frequency of severe hydro-meteorological events will increase.

General Approach for Hazard and Risk Assessment

Hazard identification and risk Assessment are generally described in Chapter 2 b of the OECD Guiding Principles for Chemical Accident, Prevention, Preparedness and Response (2003). Natural hazard sources are not directly subject of the explanations of the requirements for risk assessment in this guidance.

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45 Krausmann, E. Baranzini, D.: Natech risk reduction in OECD Member Countries: Results of a questionnaire survey, JRC 54120, 2009

46 Warm, H.J.; Köppke, K.-E.: Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Safety of new and existing facilities and establishments against natural environmental hazards, especially floods). German Federal Environment Agency, 2007, Ref.-No. 203 48 362

47 Krausmann, E; Cozzani, V.; Salzano, E; Renni, E.: Industrial accidents triggered by natural hazards: an emerging risk issue. Nat. Hazards Earth Syst. Sci., 11, 921–929, 2011

Krausmann et al. state that a specific approach for Natech risk assessment is needed, because the standard risk management procedure does not cover the special recommendations for Natech risk assessments. Therefore the authors have developed a specific procedure in order to start a risk assessment in a special project. Without discussing this project in detail the general procedure adapted to the special requirements of this project is given in **Table 1.**

Table 1. Procedure used for the analysis of the risk induced by natural events in process plants.

No.	Step Needs
1	Characterization of the natural event (frequency and severity)
2	Identification of target equipment (list of target equipment considered)
3	Identification of damage states and reference scenarios (event trees)
4	Estimation of damage probability (equipment damage models)
5	Consequence evaluation of the reference scenario (consequence analysis models)
6	Identification of credible combinations of events (set of event combinations)
7	Frequency/probability calculation for each combination (frequencies of event combinations)
8	Consequence calculation for each combination (overall vulnerability map)
9	Calculation of risk indices (overall risk indices)

Other approaches of risk assessment procedures base on different steps, so that a detailed, general applicable risk assessment method for all hazard sources can only be given with strongly generalized steps. It is necessary to discuss which steps must be basically required in Natech risk assessments. Then it has to be proven whether these steps can be integrated in the OECD guidance.

Basic Problems of Natech Risk Assessment

Galderisi et al.[48] have given a short summary of the development of Natech risk assessment during the last years. They stated that with the in depth studies, e.g. Kocaeli), a better understanding of the ''multi-faceted and difficult to predict chain effects resulting from coupling natural with technological disasters'' have been provided. The authors point out that in spite of increasing awareness on such ''combined'' events natural and technological hazards are generally still handled separately.

Furthermore, Methods and procedures aimed at taking into account simultaneous or combined hazards and their impacts are still needed to enable operators and communities to plan suitable precaution measures.

The difficulties to develop methods and procedures for Natech risk assessment are still relevant due to different factors:

- Complexity of these phenomena, deriving from the interaction of different hazard sources - natural and technological - which can impact the same objects in a different way, simultaneously or within a short time frame.
- Heterogeneous competencies are required in order to deal with Natechs; it is necessary to share knowledge in the field of both natural and technological risk assessment and management and, up to now, these fields have been scientifically and operatively separated.

48 Galderisi, A.; Ceudech, A.; Pistucci, M.: A method for na-tech risk assessment as supporting tool for land use planning mitigation strategies. Nat Hazards (2008) 46:221–241

Approaches for Natech Risk Assessment

Based on new experiences some countries have realized the problem and have integrated the consideration of natural hazards in the management of industrial safety (e.g. in safety documents) and in their national regulations during the last years. In France for example specific regulations or good practices for hazardous industrial facilities exist for earthquake, lightning, flooding, snow and wind. For other natural hazards not listed above, such as avalanche, volcanic eruption, there are no national specific regulations or best practices to their consideration. In these cases, the integration of these natural phenomena in the safety report is left to the discretion of the operator.

In Germany the Technical Rule for Plant Safety 310 considers the possible increase of hazards by precipitation and floods due to expected climate change.

Although different hazard specific approaches of risk assessment for land-use planning, siting of facilities, flood and precipitation, earthquakes, and tsunami impacts are developed, no defined general procedure for Natech risk assessment exists, which includes general necessary working steps.

Examples of best practice for Natech risk assessments are presented in the following chapters

In the frame of this discussion paper, it is not possible to describe all different approaches for Natech risk assessment. Only few will be presented in the following chapters. They all focus on one special natural hazard.

Risk assessment of earthquakes in France

A new regulation (Decrees 210-1254 and 2010-1255, dated October 22nd 2010) recently introduced a new zoning for seismic activity, dividing France into 5 areas, from areas 1 (very low seismic activity) to 5 (high activity). This regulatory change bases new scientific knowledge, which has led to a re-evaluation of seismic hazard and a re-definition of the zoning based on a probabilistic approach (taking into account the return periods).

In this context, industrial facilities in France are classified according to the properties of the handled/stored chemical products or according to their activities ("classified sites"). With regards to the regulation which establishes the rules for protection against earthquake, the classified sites may be subject to regulation applicable to "normal risk" or "special risk" installations. According to the Ministerial Order of 24 January 2011, "special risk" classified sites are pieces of equipment in low and upper-tier SEVESO establishments that may lead, in case of an earthquake, to one or more dangerous phenomena with lethal effects out of the site boundaries, unless there are no permanent human presence in this identified lethal effects area.

The elastic response spectra (vertical and horizontal) in acceleration, representing the seismic movement of one point in the surface on the right of the establishment are then elaborated, using information given in the Ministerial Order.

If the installation is new, compliance to regulation must be demonstrated when the operator submits a request for a permit to operate. Protective measures against the earthquake must then be implemented at the start of operations.

For existing establishments, a study to assess the technical measures necessary to protect from earthquakes must be carried out before December 31st 2015, and the implementation of these measures must not exceed 1st January 2021.

All other pieces of equipment in establishments that do not belong to the "special risk" category are considered as "normal risk" category. In this case, classified sites must apply the Order of 22nd October 2010 like all buildings on French territory. There are rules for new buildings, or existing buildings in specific conditions, in seismic area 2, 3, 4 and 5. The application of Eurocode 8 is required, while leaving the possibility of using standard rules in the case of simple structures. The protection level is adjusted according to the structure involved.

Natech Risk Assessment for Land Use Planning Mitigation Strategies

This Natech risk assessment method has been developed as a supporting tool for land use planning strategies aimed at reducing Natech risk in urban areas. More specifically, a multi attribute decision making method, combined with fuzzy techniques, has been developed (**Figure 12**). The authors state that "the method allows planners to take into account, according to different territorial units, all the individual Natech risk factors, measured through both quantitative and qualitative parameters, while providing them with a Natech risk index, useful to rank the territorial units and to single out the priority intervention areas. The method is designed to process information generally available about hazardous plants (safety reports), natural hazards (hazard maps) and features of urban systems mainly influencing their exposure and vulnerability to Natech events (common statistical territorial data). Furthermore, the method implemented into a GIS framework should easily provide planners with comparable maps to figure out the hazard factors and the main territorial features influencing the exposure and vulnerability of urban systems to Natech events. The method has been tested on a middle-sized municipality in the Campania Region, identified as 2nd class seismic zone, according to the Ordinance 3274/2003[49], in which a LPG storage plant, classified as a plant with major accident potential by the Seveso II Directive (Art. 9), is located just within the city core."

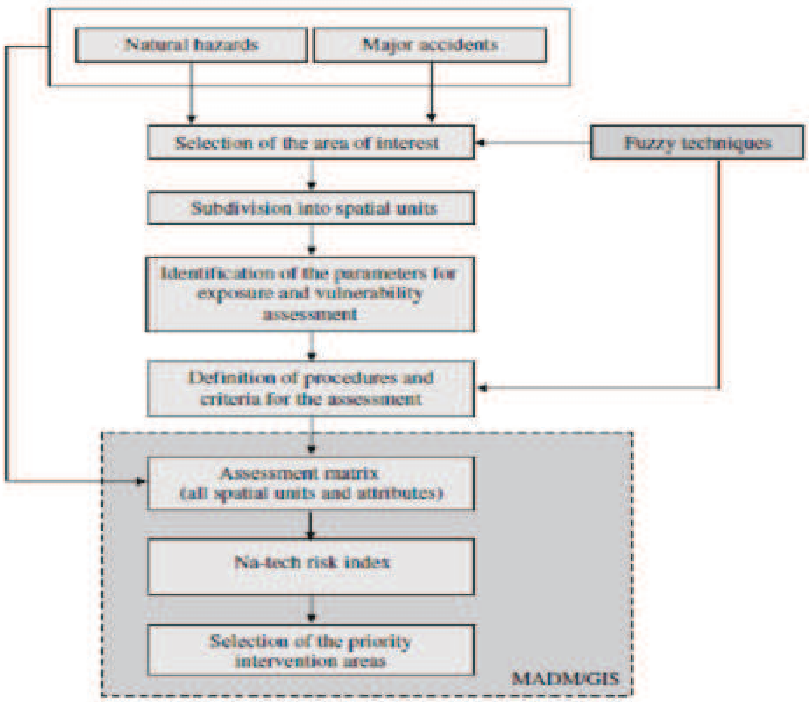

Figure 12: *Logical structure of the method*[50]

Risk Assessment for Precipitation and Floods

This method has been developed by Köppke et al. for the German Federal Environmental Agency and will be presented during the workshop in Dresden (**Figure 13**).[51]

49 L'Ordinanza del Presidente del Consiglio dei Ministri 3274/2003: Primi elementi in materia di criteri generali per la classificazione sismica del territorio nazionale e di normative tecniche per le costruzioni in zona sismica. Roma, 20 marzo 2003, Pubblicata sul Supplemento Ordinario n. 72 alla Gazzetta Ufficiale n. 105 del 8 maggio 2003

50 Galderisi, A.; Ceudech, A.; Pistucci, M.: A method for Natech risk assessment as supporting tool for land use planning mitigation strategies. Nat Hazards (2008) 46:221–241

The methodical procedure bases on four main steps:

1. Hazard source analysis, in which it is scrutinized what hazard sources could affect the site singly or in combination,
2. Analysis of hazards and threats, in which it is scrutinized whether major accidents may occur as a result of effects on safety-relevant parts of an establishment or installations,
3. Drafting of a protection concept, in which precautions to prevent major accidents are specified,
4. Examination of 'major accidents despite precautions', which leads in particular to the specification of measures to mitigate the effects of major accidents.

At the beginning of the hazard source analysis the operators have to determine possible hazard sources. Initially, a simplified hazard source analysis only identifies events in qualitative terms at the location (incl. establishments) that are possible (cannot reasonably be excluded) within the region. In a detailed hazard source analysis, further information is drawn upon in order to determine possible hazard sources more accurately.

Where hazard sources cannot reasonably be excluded, a detailed hazard source analysis is required. The foreseeable consequences of climate change should be taken into consideration in the course of a hazard source analysis, even if uncertainties naturally attach to them. With the global temperature rising as a consequence of climate change, the atmosphere's capacity to absorb water vapour will increase disproportionately. This gives reason to expect that the intensity and frequency of heavy precipitation will rise in line with the rise in temperature.

The risk assessment to be performed bases on the fact that an inundation only occurs, if the water inflow into an area is greater than the outflow. So the inflow and outflow streams must be identified.

Flood maps based on different probabilities and provided by the authorities give important information to the operators in order to perform a water balance. Data about precipitation with different intensities and recurrence intervals provided by DWD (Deutscher Wetterdienst) can easily be interrogated for the local conditions of a plant. Other information sources are topographic maps and experiences from recent events. The percolation rate of the surface water in the surroundings of the plant must be estimated. In case of covered surfaces the runoff factor is close to 1. The impact of subways, and raised railway lines or streets as barriers for runoff water must be considered. Also possible bottlenecks for the runoff water like small bridges must be identified, as floating refuse can decrease the water flow.

With this information a hazard assessment can be performed. Furthermore, with an extrapolation of the precipitation ratios extreme events can be simulated and assessed. In order to prove the results of the hazard source analysis some parameters can be varied, e.g. the percolation rate to the ground.

In the second step the endangered installations and establishments of a plant can be easily identified with the help of the calculated water depths. Using different scenarios the impact of the water on installations and establishments can be estimated.

During the third step a protection concept based on the legal requirements must be elaborated. Protection concepts are to be developed on the basis of the hazard sources that cannot reasonably be excluded, the hazards or threats that are identified, and the scenarios and protection aims. When protection concepts are elaborated, attention is to be paid to the requirement laid down in Article 3(4) of the Major Accidents Ordinance that they be consistent with the state of the art of safety technology. For the purposes of adaptation, climate change is to be taken into consideration as follows:

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[51] Köppke, K.-E.; Sterger, O.; Stock, M.: Vorkehrungen und Maßnahmen aufgrund der Gefahrenquellen Niederschläge und Hochwasser (Prevention and preparedness due to hazards by precipitation and floods). Federal Environmental Agency, Ref.-No. 3708 49 300, 2012

1. A climate adaptation factor of 1.2 is applied to the trigger event intensities to be estimated for 2010 in order to take into consideration possible changes in the period up to 2050.
2. New installations that will be designed for the period up to 2050 or after 2050 should comply with the consequent requirements.
3. The climate adaptation factor does not have to be taken into consideration if it is intended to operate a planned new installation not until 2050.
4. As of 2050, the climate adaptation factor is to be considered in the lay-out of all installations.
5. A detailed hazard source analysis may provide grounds for the 1.2 factor to be varied in an individual case. This is possible in particular if the consequences of climate change are already taken into consideration on (flood) hazard maps or the authority responsible for the water in question has previously ascertained the possible change in the runoff from high water flooding due to climate change.
6. Should other developments in what is known about climate come to light in the period up to 2050, they will be taken into consideration when this Technical Rule on Process Safety is revised.

Step four requires the examination of ‘major accidents despite precautions’. Such events occur, if all precaution measures fail. Especially the determination of required response and mitigation measures including emergency planning should base on assumed effects of extreme events.

This shortly described procedure was tested successfully for a plant of the chemical industry.

The German Technical Rule on Process Safety (TRAS 310) “Precautions and Measures against the Hazard Sources Precipitation and Flooding” was developed on the basis of the methodology and includes the requirements on protection aims listed above.

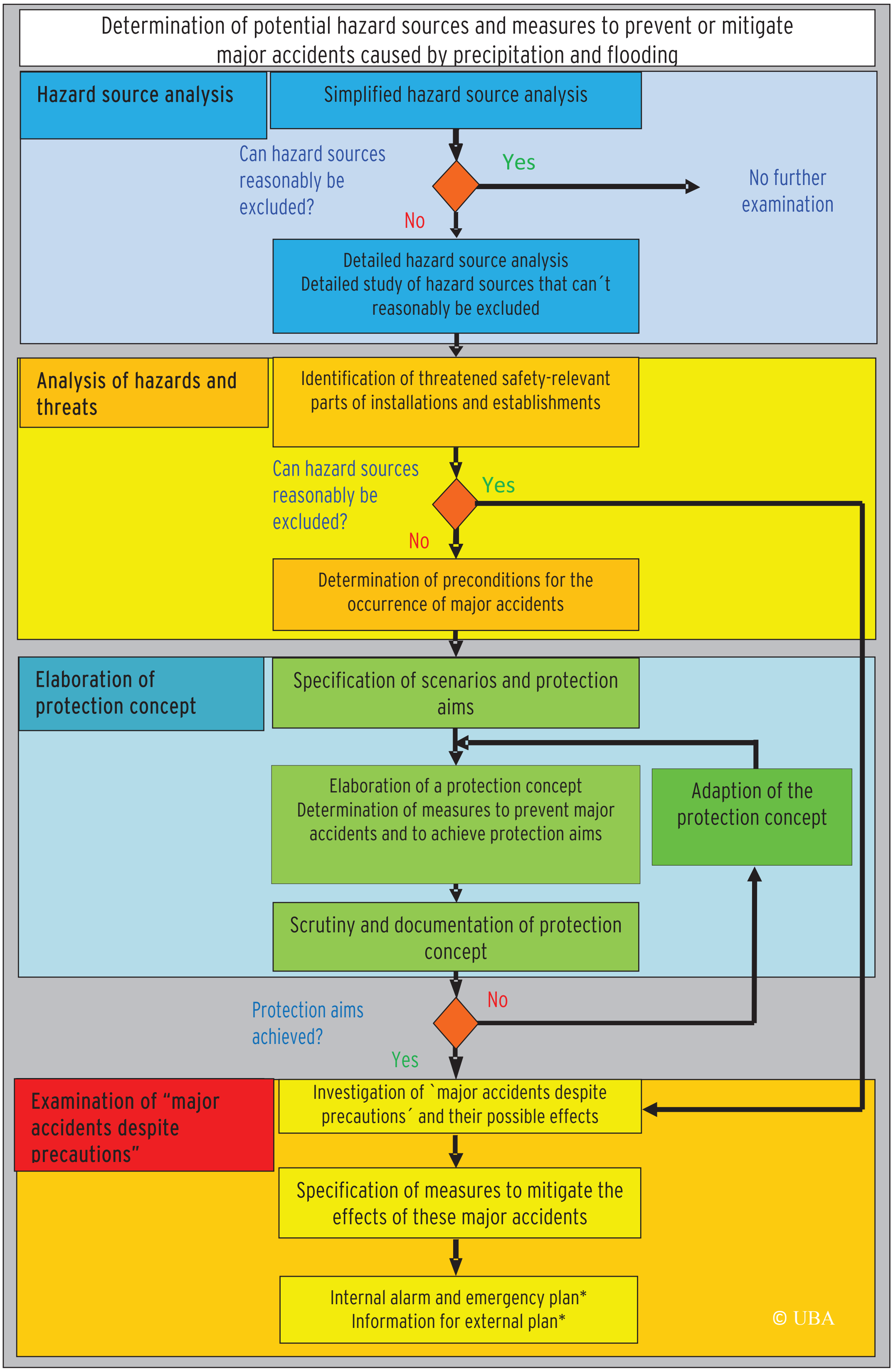

Figure 13: *Flow chart for the optimization of a protection concept (*if required)*[52]

[52] Translation from Table 1 of the Technische Regel für Anlagensicherheit (Technical Rule on Installation Safety) 310, Bundesanzeiger 2012 Nr. 32a in Short Version of: Köppke, K.-E.; Sterger, O.; Stock, M.: Vorkehrungen und Maßnahmen aufgrund der Gefahrenquellen Niederschläge und Hochwasser (Prevention and preparedness due to hazards by precipitation and floods). Federal Environmental Agency, Ref.-No. 3708 49 300, 2012

Risk Assessment for Flood in France

International databases show that floods accounted for more than half of disasters registered for the 1990-2001 period. With consequences of climate change largely unpredictable at local level, future statistics are not likely to show any improvement. In response to such natural-technological interaction, mitigation efforts have taken two main directions: land-use planning in flood-prone areas; vulnerability reduction in flood-prone facilities. This communication focuses presents good practice accumulated in France for the mitigation of flood impacts on industrial facilities.

INERIS[53] proposes to present a methodology for the integration of flood hazard in risk-reduction process for industrial plants. Both floods originated from a dam rupture and unusual rainfalls will be considered.

This methodology follows a sequence in 4 steps.

1. The first step aims at determining whether the studied plant is located in a floodable area or not. If it is the case, data are needed to better understand the flooding, such as type of flooding, water height, flow velocity, speed of water level rising, flooding duration, return period of flood…
2. Based on information gathered in step 1, the topography of the industrial plant, the location of buildings and facilities within plant perimeter, areas which could be affected by flooding are identified. In the potentially flooded areas, facilities and equipments that could cause major technological accidents are identified. A systematic risk analysis is then performed for each of these equipments. The accidental sequences leading to dangerous phenomena (fire, explosion, toxic cloud dispersion, pollution…) are detailed, and existing safety barriers are highlighted.
3. The safety barriers are analyzed more in details in terms or performance (efficiency, maintainability, testability…). Each barrier shall be assessed also in terms of kinetics, depending on implementation time, availability of human resources, technical devices… Depending of the available time before the arrival of water and resources in case of flooding, some safety barriers are also selected for risk assessment and emergency plan.
4. A final analysis should assess if all barriers can be implemented at the same time, taking into account the available personal and the available time between the information of flood threat and the flood itself.

A suggestion of possible safety barriers against flood will be made by INERIS.

Analysis of Tsunami Impact Scenarios at an Oil Refinery[54]

Based on tsunami source data for two credible tsunami scenarios provided by the University of Bologna, tsunami flow velocities and maximum water surface levels along the northern coast of Sicily were simulated using the JRC code HyFlux2, developed to simulate severe inundation scenarios due to dam breaks, flash floods and tsunami-wave run-up.[55] The potential for damage and hazardous materials releases resulting from the tsunami impacts to a refinery was assessed.

The results indicate that in both scenarios there would be eighteen storage tanks (of 43 located within 400 m from the shoreline) at the refinery subject to flooding. Water flow velocities were found to be generally low, <1 m/s, except for a central section of the refinery near the shoreline where the water flow velocities reach 3-4 m/s. These results indicate that any damage would most likely occur due to buoyancy loads particularly in the western part of the facility where inundation levels are higher and storage tanks are less protected.

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53 INERIS: Institut National de l`Environnement industriel et des Risques

54 Cruz, A.M.; Krausmann, E.; Franchello, G.: Analysis of tsnumi impact scenarios at an oil refinery. Nat Hazards (2011) 58:141–162

55 Franchello G, Krausmann E (2008) HyFlux2: a numerical model for the impact assessment of severe inundation scenario to chemical facilities and downstream environment. EUR 23354 EN, European Communities

Potential damage caused by impact of floating debris may be a problem in the central area of the refinery near the shoreline due to high flow velocities (3-4 m/s) in both tsunami scenarios. Small hazardous materials releases could occur due to breakage of connected pipes and flanges caused by floating materials, e.g. almost empty storage tanks or other equipment.

Salt water intrusion could affect electrical equipment, such as control panels, pumps, and motors that are not raised above the inundation level. We conclude that in the two tsunami scenarios analysed, the risk to nearby residents and neighbouring facilities from potential hazardous materials releases, fires or explosions triggered by the tsunamis is likely to be small. Nonetheless, recommendations are made on prevention measures to reduce the risk of tsunami-triggered accidents and to mitigate their consequences if they do occur. The results of this study are limited by the uncertainty in the input data and most importantly by the accuracy of the elevation data and the model resolution.

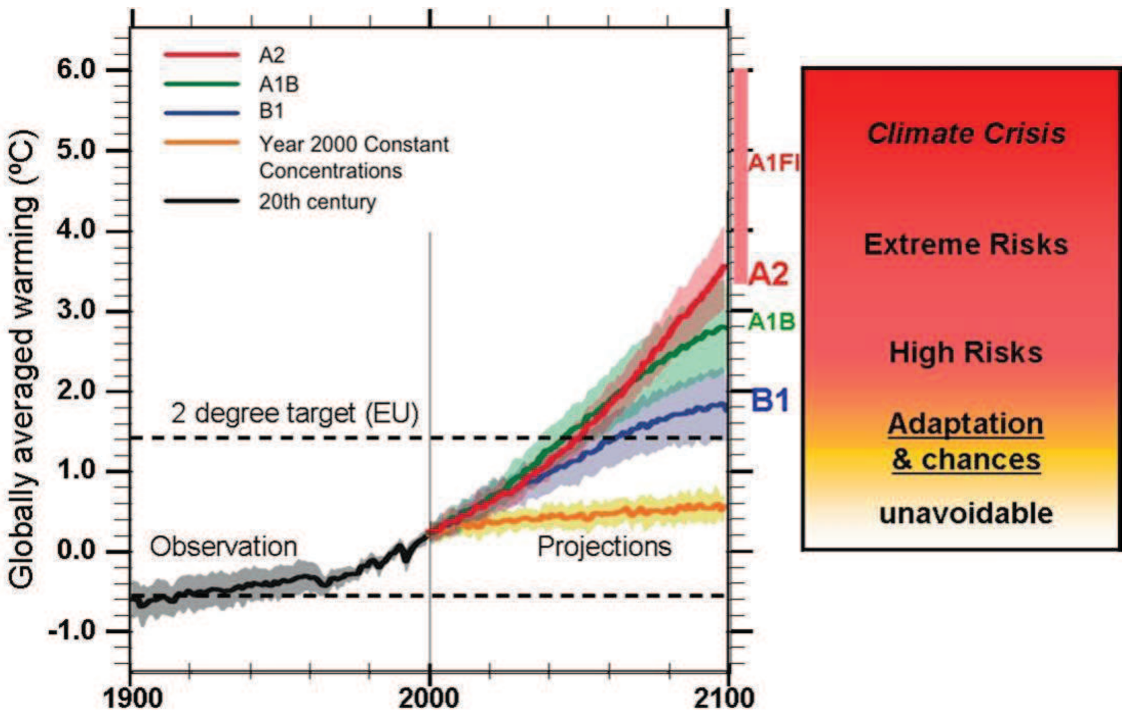
Issues Requiring Further Discussion:

1. How to improve awareness raising on Natechs and risk communication among all stakeholders, i.e. at all levels of the government, in industry, within communities and the public?
2. What are the roles and responsibilities of key stakeholders - industry/operator, government/authorities and communities/public - in the management of Natech risks?
3. How can all parties best prepare for the challenges posed by (major) Natech risks?
4. Is there a need for training of chemical-accident and natural disaster managers and officials on Natech risk management?
5. How should Natech accidents and risk reduction be taken into account in the national chemical accidents programmes in order to guarantee effective Natech risk management?
6. Should there be an explicit legal obligation that plant operators have to consider Natechs as a part of the overall hazard identification and risk management process?
7. Should special Natech regulations and guidance provide industry/operators and authorities/inspectors, how to integrate Natech events in the existing regulations for safety management, safety reports, inspections and Natech risk assessment?
8. Should Natech regulations or guidance include the following general aspects:
    - Natech risk assessment which includes the following key aspects:
        - Identification of natural hazards,
        - Identification of endangered establishments and installations,
        - Drafting a protection concept,
        - Emergency preparedness and planning including the characteristics of Natech accidents (e.g. a possible lack of utilities);
    - Information and training of the staff, and
    - Cooperation between operators, authorities and communities?
9. How can countries share existing good practices for Natech risk reduction?
10. Should the main key points of Natech risk assessment consistently be defined by the OECD member countries in order to assure an integrative standard?
11. Which subjects related to Natechs should have priority in future Natech research?

Session III: Consideration of Climate Change in Natech Risk Management

Introduction

A changing climate, including increased temperatures, changes in precipitation patterns, sea level rise, and more frequent extreme weather events will pose many challenges to industry plants. Over the entire 20th century the measurement of the global temperature has increased around 0.6°C. Based on Special Reports on Emissions Scenarios (SRES), which uses the Intergovernmental Panel on Climate Change (IPCC) for the projection of future scenarios, the temperature increases like illustrated in **figure 14**.



Figu*re 14*: *Global Warming at the surface of the earth in °C (relative to 1980 -1999) for different SRES scenarios (Source: IPCC Fourth Assessment Report, Summary for Policy Makers.)*

For the lowest emissions SRES marker scenario "B1", the best estimate for global mean temperature is an increase of 1.8 °C (3.2 °F) by the end of the 21st century. This projection is relative to global temperatures at the end of the 20th century. For the highest emissions SRES marker scenario (A1FI), the best estimate for global mean temperature increase is 4.0 °C (7.2 °F), with a "likely" range of 2.4–6.4 °C (4.3–11.5 °F).

The range in temperature projections partly reflects the different choice of emissions scenario. Different scenarios make different assumptions of future social and economic development (e.g., economic growth, population level, energy policies), which in turn affects projections of greenhouse gas (GHG) emissions. The range also reflects uncertainty in the response of the climate system to past and future GHG emissions (measured by the climate sensitivity).

Effects on Weather

Observations show that there have been changes in weather. As climate changes, the probabilities of certain types of weather events are affected.

Precipitation and Draught

With increasing temperature the water capacitity of the atmosphere increases too. As a result more intensive precipitation has to be expected. According to the equation of Clausius-Clapeyron the water capacity rises about 6 up to 7 % with a temperature increase from 20 to 21°C:

(1) $$de_s(T) / e_s(T) = L\, dT / R\, T_2$$

$e_s(T)$ = saturation steam pressure
L = enthalpie of evaporation
R = gas constant

Equation (1) means that the saturation steam pressure increases exponentially with increasing temperature. Stock has derived from equation (1) that the potential water volume in the atmosphere can be estimated easily with the following equation (2):[56]

(2) $$W(T) = w_0 + w_1 \exp(w_2 \Delta T)$$

The factors w_0, w_1 und w_2 depend on the regional climate and geographic conditions and must be calculated from observed data.

Changes have been observed in the amount, intensity, frequency, and type of precipitation. Widespread increases in heavy precipitation have occurred, even in places where total rain amounts have decreased. Authors of the IPCC Fourth Assessment Report concluded that human influences had, more likely than not (greater than 50% probability, based on expert judgement), led to an increase in the frequency of heavy precipitation events. As a result the risk of inundation will also increase, especially along river basins.

The number of flood disasters globally has been steadily increasing since 1974, and accounted for about 34% of all natural disasters in the world between 1974 - 2003[57]. In general, flood loads include loads due to standing or slowly moving water, buoyant loads, loads due to fast moving water, breaking wave loads, and impact loading which results from floating debris. Higher water speeds and higher water depths increase flood loads. Facilities located in river basins and near large water bodies may be subject to flood loads. This impact will become increasingly important.

During summer extremes of summer dryness are projected for much of the globe. Those draughts must be considered by the plant managers especially for dimensioning fire fighting water supply.

Wind and Storm

Evidence suggests that, since the 1970s, there have been substantial increases in the intensity and duration of tropical storms and hurricanes. Models project a general tendency for more intense but fewer storms outside the tropics. It is reported that major storm disasters have occurred in the last two decades. Cruz and Krausmann determine the damages in the oil and gas sector caused by extreme weather events.[58] In the summer of 2005, Hurricanes Katrina and Rita were responsible for one of the worst disasters in U.S. history. They triggered more than 200 hazardous-materials releases from industrial facilities and storage terminals along the coast.

During hurricanes Katrina and Rita, power supplies were severe affected, as approximately 1,000,000 wooden poles and approximately 300 tower or steel poles collapsed due to wind forces.[59]

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56 Stock, M.: Klimawandel - Konsequenzen für die Siedlungsentwässerung?, DWA-Expertengespräch, Hennef/Sieg, 22. Februar 2006

57 Hoyois, P., and D. Guha-Sapi: Disasters caused by flood: Preliminary data for a 30 year assessment of their occurrence and human impact. Health and Flood Risk Workshop: A Strategic Assessment of Adaptation Processes and Policies. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, 18-20 July, 2004

58 Cruz, A.M.; Krausmann, E.: Vulnerability of the oil and gas sector to climate change and extreme weather events. Submitted to a Special Issue in the journal Climate Change, 2010

59 American Society of Civil Engineers: Wind Loads for Petrochemical and Other Industrial Facilities. 2011, ISBN 13: 978-0-7844-11108-3

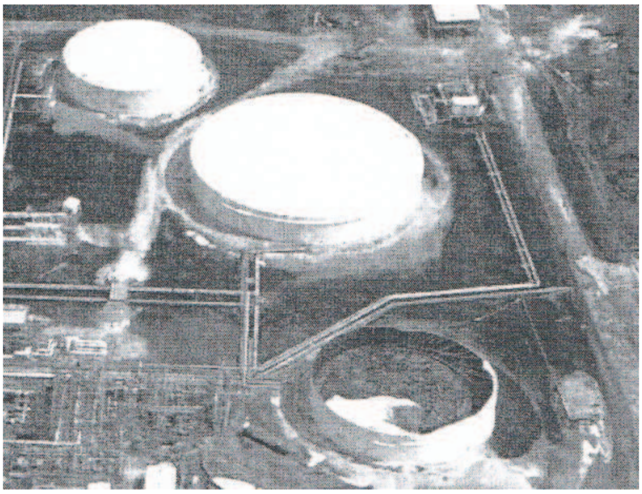

Figure 15: *Tank Damage – Hurricane Katrina (Photo Courtesy of NOAA)*

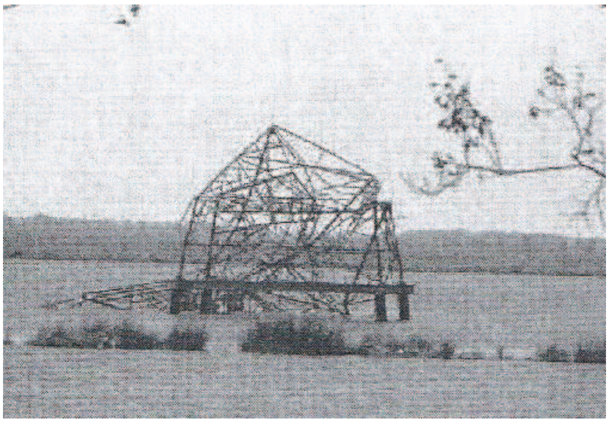

Figure 16: *Electrical Transmission Tower – Hurricane Rita (Photo Courtesy of NIST)*

Other Hurricane e.g. Hugo, 1989 left also a mark of damages.

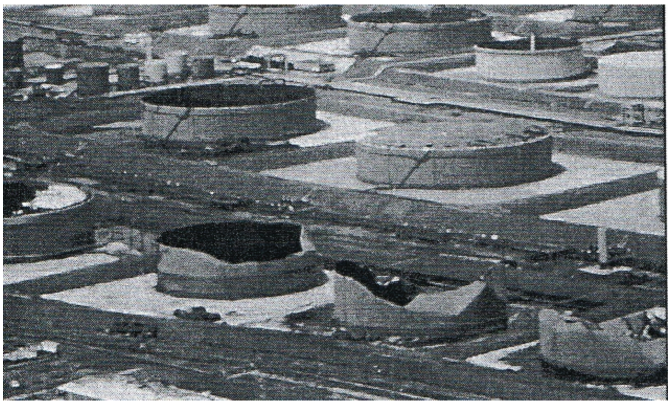

Figure 17: *Petroleum Storage Tank – Hurricane Hugo (Photo Courtesy of NOAA)*

According to the general codes for the structural design of buildings a collapse of the building of must be avoided in order to safe human lives. Damages like cracks in walls or floors are tolerated as long as the building does not collapse. According to this general safety concepts the loads caused by wind and storm are considered in the different codes for the design of the supporting structure.

However, the safety concept for buildings does not consider the requirements for a safety concept for installations and establishments of industrial plants. For example, cracks of pipelines with a release of hazardous substances cannot be tolerated.

Furthermore, debris caused by wind and storm are not subjects of the design codes for the construction of industrial plants.[60]

Extreme Weather Events

Since the late 20th century, changes have been observed in the trends of some extreme weather and climate events, e.g., heat waves. Human activities have, with varying degrees of confidence, contributed to some of these observed trends. Projections for the 21st century suggest continuing changes in trends for some extreme events. Solomon et al., for example, projected the following likely (greater than 66% probability, based on expert judgement) changes:

- an increase in the areas affected by drought;
- increased tropical cyclone activity;
- an increased incidence of extreme high sea level (excluding tsunami).

The IPCC (2007) states that in a warmer future climate, there will be an increased risk of more intense, more frequent and longer-lasting heat waves. The European heat wave of 2003 is an example of the type of extreme heat event lasting from several days to over a week that is likely to become more common in a warmer future climate. A related aspect of temperature extremes is that there is likely to be a decrease in the daily (diurnal) temperature range in most regions. It is also likely that a warmer future climate would have fewer frost days (i.e., nights where the temperature dips below freezing).

In a warmer future climate, most Atmosphere-Ocean General Circulation Models project increased summer dryness and winter wetness in most parts of the northern middle and high latitudes. Summer dryness indicates a greater risk of drought. Along with the risk of drying, there is an increased chance of intense precipitation and flooding due to the greater water-holding capacity of a warmer atmosphere. This has already been observed and is projected to continue because in a warmer world, precipitation tends to be concentrated into more intense events, with longer periods of little precipitation in between. Therefore, intense and heavy downpours would be interspersed with longer relatively dry periods. Another aspect of these projected changes is that wet extremes are projected to become more severe in many areas where mean precipitation is expected to increase, and dry extremes are projected to become more severe in areas where mean precipitation is projected to decrease.

In concert with the results for increased extremes of intense precipitation, even if the wind strength of storms in a future climate did not change, there would be an increase in extreme rainfall intensity. In particular, over northern hemisphere, an increase in the likelihood of very wet winters is projected over much of central and northern Europe due to the increase in intense precipitation during storm events, suggesting an increased chance of flooding over Europe and other mid-latitude regions due to more intense rainfall and snowfall events producing more runoff. Similar results apply for summer precipitation, with implications for more flooding in the Asian monsoon region and other tropical areas. The increased risk of floods in a number of major river basins in a future warmer climate has been related to an increase in river discharge with an increased risk of future intense storm-related precipitation events and flooding. Some of these changes would be extensions of trends already underway.

Studies show that with increasing temperature tropical cyclones could become more severe, with greater wind speeds and more intense precipitation in future. There are indications that the average number of Category 4 and 5 hurricanes per year has increased over the past 30 years. Some modelling studies have projected a decrease in the number of tropical cyclones globally due to the increased stability of the tropical troposphere in a warmer climate, characterised by fewer weak storms and greater numbers of

[60] Krätzig, W.; Niemann, H.-J., Köppke, K.-E., Stock, M.: Vorkehrungen und Maßnahmen aufgrund der Gefahrenquellen Wind und Schnee unter Berücksichtigung des Klimawandels. (Prevention and Preparedness due to Hazards by Wind and Snow) Forschungsvorhaben des Umweltbundesamtes, Zwischenbericht 2012, unpublished.

intense storms. A number of modelling studies have also projected a general tendency for more intense but fewer storms outside the tropics, with a tendency towards more extreme wind events and higher ocean waves in several regions in association with those deepened cyclones. Models also project a shift to the poles of storm tracks in both hemispheres by several degrees of latitude.

Other Natural Hazard Sources Affected by Climate Change

Earthquakes

Earthquakes can damage industrial buildings, process equipment, storage tanks and pipelines containing hazardous materials possibly leading to the release of substances dangerous for the population and the environment. Furthermore, safety and mitigation measures that would normally be available to prevent or mitigate releases may not be operational due to power outages, loss of cooling- or fire-fighting water due to pipe breaks, or concurrent damage to safety systems and related equipment by the earthquake. Hazardous-materials releases in the form of oil spills, toxic gas releases, fires and explosions can result in off-site impacts to nearby communities imposing a further burden on the natural-disaster victims, hampering emergency response, contaminating the environment, and possibly resulting in liability costs that will greatly add to the economic losses suffered by a facility. Moreover, earthquakes usually have an extended impact radius, can trigger secondary hazard events such as tsunamis, landslides or dam breaks, and can lead to releases from multiple sources at one chemical facility or from several affected hazardous installations simultaneously. Domino effects, in which an accident in one installation triggers a secondary accident in the same or in one or more neighbouring establishments, also occur more frequently during Natech accidents. The possible impacts of earthquakes is presented in the case studies, which has been elaborated for this workshop.

A numerical modelling study has demonstrated that seismicity increases during unloading, such as that due to the removal of ice.

Oceans

The role of the oceans in global warming is a complex one. The oceans serve as a sink for carbon dioxide, taking up much that would otherwise remain in the atmosphere, but increased levels of CO_2 have led to ocean acidification.

Furthermore, as the temperature of the oceans increases, they become less able to absorb excess CO_2. The oceans have also acted as a sink in absorbing extra heat from the atmosphere. This extra heat has been added to the climate system due to the build-up of greenhouse gases. More than 90 percent of warming that occurred over 1960 - 2009 is estimated to have gone into the oceans.

Global warming is projected to have a number of effects on the oceans. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation.

A report from the U.S. Climate Change Science Program (CCSP 2007) found that overall the effects of climate change on the energy infrastructure in the United States might be categorized as modest. However, the report says that local and industry-specific impacts could be large, especially in areas that may be prone to weather disruptions such as the U.S. Gulf Coast and Gulf of Mexico. Other low lying coastal areas are home to some of the world's largest oil and gas facilities (e.g., Ras Tanura, Saudi Arabia; Jamnagar, India; Jurong Island Refinery, Singapore; Rotterdam Refinery and major installations in the Niger Delta) leaving them exposed to coastal flooding and storm surge, rising sea-levels, and ground subsidence and erosion.[61] Sea level rise could make much of the existing infrastructure more prone to frequent or permanent inundation, and warmer temperatures are likely to increase costs of design, construction, maintenance and operations.

Wildfires

In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of wild fire events.

Lighting

Numerous studies indicate that lightning strikes are the natural hazard that most frequently triggers accidents in processing and storage activities.[62] Lightning interacts with industrial structures either by direct strike, the build-up of the bound charge and secondary sparking or by the disruption of electrical control and safety systems (US EEP 1997, American Petroleum Institute 2008).[63]

Rasmussen analysed accident case histories in the industrial accident databases MHIDAS and FACTS and concluded that 61% of the accidents initiated by natural events at storage and processing activities were triggered by lightning strikes.[64] Lightning was also found to be the most frequent cause of failure in the set of storage tank accidents. Storage tanks containing flammable substances are of particular concern in the presence of lightning risk as they represent a fire or explosion hazard in the event of a lightning strike. Climate models show more lightning with less rainfall in the future.[65]

Issues Requiring Further Discussion

According to the international knowledge of the IPCC a climate change exist and can be observe since recent years.

Projections of future trends of climate change based on scenarios of Greenhouse Gas Emissions. Different scenarios make different assumptions of future social and economic development (e.g., economic growth, population level, energy policies), which in turn affects projections of greenhouse gas (GHG) emissions. For the lowest emissions scenario, the best estimate for global mean temperature is an increase of 1.8 °C (3.2 °F) by the end of the 21st century. For the highest emissions scenario, the best estimate for global mean temperature increase is 4.0 °C (7.2 °F), with a "likely" range of 2.4–6.4 °C (4.3–11.5 °F).

Besides the long-term global warming the climate change will influence intensity, frequency, and occurrence of extreme events. Natural hazards to be considered by the facility operators will be influenced by the effects of the climate change.

1. How can the impact of the climate change be considered by the plant operators in siting of new facilities and in the risk management?
2. How can national strategies and measures for climate change adaption consider the risk of Natechs?
3. How to deal with uncertainty of climate change projections and estimations on consequences for natural hazards in that context?

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61 Paskal, C. (2009). The Vulnerability of Energy Infrastructure to Environmental Change. Briefing Paper. A joint publication of Chatham House and Global Energy & Environment Strategic Ecosystem (EESE), EERG BP 2009/01, UK. <Retrieved 8 March 2010> http://www.chathamhouse.org.uk/research/eedp/papers/view/-/id/737/

62 J.I. Chang, C.-C. Lin, A study of storage tank accidents, J. Loss Prev. 19 (2006) 51–59.

63 United States Environmental Protection Agency, Lightning hazard to facilities handling flammable substances, EPA 550-F-97-002c, May 1997.

64 K. Rasmussen, Natural events and accidents with hazardous materials, J. Hazard. Mater. 40 (1995) 43–54.

65 Price, P.: Thunderstorms, Lightning and Climate Change. 29th International Conference on Lightning Protection, 2008, Uppsala, Sweden

Session IV: Application of the Polluter-Pays-Principle to Natechs

Introduction

Subject of Session IV are the OECD-Recommendations relevant for the liability of operators in case of Natechs. Main issue is how fare operators shall be held liable for the damage to persons, property and the environment due to causes of a Natech according to the national legislation. In case of Natechs the OECD Recommendations allow an exemption from this liability and the conditions of this exemption shall be further defined.

This does not address:

1. Design or lay-out criteria for measures to prevent Natechs
2. Criteria for the conception of mitigation measures in case of Natechs
3. Insurance conditions like limitations concerning the severity of the natural impact or the coverage
4. Insurance of the damage of the operator's facility in case of natural events.

OECD Recommendations and UNECE Conventions

The three OECD Recommendations of the Council related to the Polluter Pays Principle (PPP)[66],[67],[68] issued in 1972, 1974 and 1989 respectively are important Council Acts the OECD in the field of environmental policy.

The 1972 Recommendation on Guiding Principles concerning International Economic Aspects of Environmental Policies lays out the elements of the Polluter Pays Principle, and also pioneers the environmental links to other important concepts, such as 'harmonisation' and 'mutual acceptance'. The main idea contained in this Recommendation was that polluters themselves should bear the cost of implementing environmental protection measures that are decided by governments.

The 1974 Recommendation on the Implementation of the Polluter Pays Principle clarifies the conditions under which 'aid' provided to polluters would be considered to be in violation of the PPP, and it reinforces the view that any aid related to pollution control costs should be strictly time-limited. One question that arises, however, is whether a polluter should pay for pollution damage (residual pollution) when he has taken all the measures introduced by public authorities.

The 1989 Recommendation Concerning the Application of the Polluter Pays Principle to Accidental Pollution extends the PPP logic to the case of accidental pollution at hazardous installations. It is stated that "the polluter should bear the expenses of carrying out the pollution prevention and control measures introduced by public authorities in member countries, to ensure that the environment is in an acceptable state".

One exemption is

"if the accidental pollution is caused by an event for which the operator clearly cannot be considered liable under national law, such as a serious natural disaster that the operator cannot reasonably have foreseen".

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66 OECD Recommendation (1972) on Guiding Principles Concerning International Economic Aspects of Environmental Policies [C(72)128]

67 OECD Recommendation (1974) on the Implementation of the Polluter Pays Principle [C(74)223]

68 OECD Recommendation (1989) Concerning the Application of the Polluter Pays Principle to Accidental Pollution [C(89)88]

This statement would need to be developed in order to provide more guidance on these issues to public and private stakeholders.

The UNECE convention on the transboundary effects of industrial accidents (1992) addresses the issues of liability in its article 13 but includes no further guidance.

More guidance includes the UNECE Protocol on civil liability and compensation for damage caused by the transboundary effects of industrial accidents on transboundary Waters (2003) to the 1992 Convention on the protection and use of watercourses and international lakes and to the 1992 Convention on the transboundary effects of industrial accidents". Article 4 states in "Strict liability", point 2b:

1. The operator shall be liable for the damage caused by an industrial accident.
2. **No liability in accordance with this article shall attach to the operator, if he or she proves that, despite there being in place appropriate safety measures, the damage was:**

a) the result of an armed conflict, hostilities, civil war or insurrection;

b) the result of a natural phenomenon of exceptional, inevitable, unforeseeable and irresistible character;

Like the OECD recommendations the last sentence would require further elaboration to describe clearly the (level of) liability of operators.

Remarkable differences to the OECD Recommendations are:

1. The OECD recommendations **allow** the member countries **to exempt** the operator from his liability for damage by Natechs due to "exceptional events" and the UNECE Protocol recommends that **no liability shall attach** the operator in this case.
2. The UNECE Protocol defines four criteria for the damage by Natechs due to "exceptional events":
   a) exceptional (the natural event)
   b) inevitable (in the protocol linked with the natural event, but makes only sense as criteria of the Natech and the damage caused
   c) unforeseeable (the natural event but may be the Natech caused as well)
   d) irresistible (the natural event)
3. The UNECE Protocol includes these four criteria in an enumeration i. e. only natural events, Natechs or damages due to Natechs are excluded **that meet all four criteria**.

These four criteria can serve as a basis for further guidance for the exemption from liability in case of Natechs.

EU Environmental Liability – Directive 2004/35/EC[69]

This EC directive whose main objectives include the application of the "polluter pays" principle, establishes a common framework for liability with a view to preventing and remedying damage to animals, plants, natural habitats and water resources, and damage affecting the land. The liability scheme applies to certain specified occupational activities and to other activities in cases where the operator is at fault or negligent. The public authorities are also responsible for ensuring that the operators responsible take or finance the necessary preventive or remedial measures themselves.

[69] Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage

The principle of liability applies to environmental damage and imminent threat of damage resulting from occupational activities, where it is possible to establish a causal link between the damage and the activity in question.

The first liability scheme of the directive applies to the dangerous or potentially dangerous occupational activities listed in Annex III to the Directive. These are i.a. industrial activities requiring a licence under the Directive on integrated pollution prevention and control, installations producing dangerous chemical substances, waste management activities (including landfills and incinerators). Under this first scheme, the operator may be held responsible even if he is not at fault.

The second liability scheme applies to all occupational activities other than those listed in Annex III to the Directive, but only where there is damage, or imminent threat of damage, to species or natural habitats protected by Community legislation. In this case, the operator will be held liable only if he is at fault or negligent.

The Directive provides for a certain number of exemptions from environmental liability. The liability scheme does not apply in the case of damage or imminent damage resulting from armed conflict, "natural disaster", activities covered by the Treaty establishing the European Atomic Energy Community, national defence or international security activities or activities covered by the international conventions listed in Annex IV.

The exemption in case of "natural disasters" is further defined in Article 4 of the directive:

"This Directive shall not cover environmental damage or an imminent threat of such damage caused by:

a) …

b) a natural phenomenon of **exceptional, inevitable** and **irresistible** character."

The exemption in the EU Environmental liability – Directive bases on three of the four criteria in die UN-ECE protocol. Only the term "unforeseeable" is not included, but could be covered by the term "exceptional".

Criteria for Relevant Natural Events and Natechs

Two of the four criteria describe the characteristics of the natural event, one of them the character of the Natechs caused and one criteria can be applied to both.

exceptional

The word itself means "well above average or surpassing what is common or usual or expected".

In case of Natechs this can be interpreted as a natural hazard of low probability. For definition of the relevant probability qualitative and quantitative scales can be used.

Probability stage	E	D	C	B	A
Qualitativ (only applicable, on the basis of a sufficient number of cases)	„possible event, but extreme less likely“ *According to the actual state of knowledge not impossible, but did not occur world-wide for a lot of years at a lot of sites or facilities*	„very less likely event“ *Did happen under similar conditions, but prevention measures are implemented causing a significant reduction of probability of re-occurance*	„less likely event“ *Did happen worldwide under similar conditions without implementation of measures making sure a significant reduction of probability of re-occurance*	„likely event“ *Did or could happen during the lifetime of a site or facility*	„common event“ *Did or could happen during the lifetime of the site or facility despite corrective measures*
Quantitative (per year)	10^{-5}	10^{-4}	10^{-3}	10^{-2}	

Table 1. *Basing on: National Scale on the Probability of Major Accidents, for use in hazard analysis according to the French PCIG-decree of 29th September 2005)*

In the context discussed here only the stages E and D seem to be compatible with the term "exceptional".

unforeseeable

The term "unforeseeable" does not fit to any of the qualitative criteria in the table.

If the term is applied to natural hazards it could be interpreted according the qualitative criteria used for assessment of them as: "above the most intense event recorded under similar conditions (e.g. same location) or expected due change of conditions (e.g. change in land use, climate change)".

If the term is applied to Natechs it could be interpreted as: "event with effects above those regarded as possible according to scientific knowledge according".

irresistible

This term describes natural events that are not able to be resisted i.e. events with an intensity not allowing to prevent a chemical accident or mitigate it´s consequence according to the state of the art.

inevitable

This term can describe Natechs that are unavoidable and the characterisation above could be applied as well i.e. a Natech not possible to prevent or mitigate it´s consequences according to the state of the art.

Issues Requiring Further Discussion

The exemption from liability of operators in OECD Recommendations requires further guidance in case of Natechs.

1. Should the criteria in the correspondent UNECE protocol should be used for this guidance?
2. Should therefore be recommended that the OECD member countries allow only an exemption from liability of the operators for the damage caused by Natechs if a technical/chemical accident triggered by a natural hazard (Natech) was **unforeseeable, irresistible and inevitable**?
3. Should the following definitions be used in this context?

A Natech was unforeseeable if the underlying natural event had effects above those regarded as possible according to scientific knowledge, especially the effects of the natural event were above those of the most intense event recorded under similar conditions (e.g. same location) or expected due change of conditions (e.g. change in land use, climate change).

A Natech was irresistible if the underlying natural event had an intensity not allowing to prevent the chemical accident or mitigate its consequences according to the state of the art.

A Natech was inevitable if it was not possible to prevent the chemical accident or mitigate its consequences according to the state of the art.

Session V: International Cooperation

International co-operation is required in Natech

1. prevention and preparedness
2. response.

Some projects in international co-operation include all three aspects.

Due to the experiences in recent years there are many international co-operations founded in different regions in the world. As examples only few can be presented in this paper.

Baltic Sea Region

The risks of contamination of the Baltic Sea have increased since the European Union has generated the borderless socioeconomic maritime region. Due to the growth from energy transportations and logistic highways many storage tanks, pipelines, liquid cargo terminals are in operation around and under the Baltic Sea. The Council of the Baltic Sea States (CBSS) intensifies the cooperation of countries and the different institution for civil security (**Figure 18**).

Figure 18*:* *Member states and institutions involved in civil security in the Baltic Sea region*

Figure 19 illustrates the assignments of the council in the field of civil and environmental protection.[70]

Council of the Baltic Sea States (CBSS)

Lead countrv function for Civil Securitv

Risk Management and Spatial Development

Pilot projects on chemical and ecological risk assessment for urban areas.

Pilot projects regarding flood risk to cultural and natural heritage.

Pilot projects on assessment of transboundary risks related to sea transport or dangerous materials.

Establishments of BSR

Research Network on Civil Protection

Building Transnational Capacity – Exercises, Training, Education and Research

Pilot project on transboundary cooperation during liquidation disasters` consequences

Oil spill exercises

Pilot project regarding flood risk to cultural and natural heritage

Sea/Land activities – interface between resources, experiences and education for rescue missions at sea

Promoting Safety over Sectors and Borders

Regional guidelines on safety promotion within communities

Network for Safe

Communities within BSR

Safety education program

Figure 19: *Assignments of the council in the field of civil and environmental protection*

As an example **figure 20** shows the different pipelines in and around the Baltic Sea as a potential hazard source. Many plant and gas and oil storage tanks are involved in the pipe network.

Figure 20: *Pipeline network in the Baltic Sea Area*

[70] Hellenberg, T.: Intergovernmental cooperation for civil protection at the Baltic Sea region challenges and possibilities. Baltic Sea Seminar, 12 March 2008

Table 2 summarizes the essential intergovernmental agreements to tackle cross-border risk within the Baltic Sea Region.

Table 2: *Essential intergovernmental agreements*

	Nordic Mutual Emergency Assistance	Copenhagen Agreement	Nordic Agreement to prevent damage to people, property, environment	Emergency Prevention, Preparedness and Response	Eurobaltic Civil Protection Program	Cooperation within field of Emergency Prevention, Preparedness and response
Year	1963	1971	1989	1991	2001	2005
Field	Radiation Accidents	Oil Spills	All major accidents	Arctic accidents	Natural, Man-made	Emergencies
Forum	Nordic	Nordic	Nordic (Iceland 01)	Arctic Council	CBSS	Barents Euro-Arctic Council
Denmark	X	X	X		X	
Finland	X	X	X	X	X	X
Norway	X	X	X	X	X	X
Sweden	X	X	X	X	X	X
Germany					X	
Estonia					X	
Latvia					X	
Lithuania					X	
Poland					X	
Russia				X	X	X

Asian-Pacific Region

Due to many natural disasters in the Asian-Pacific Region many countries have founded international or bilateral cooperation in risk monitoring and disaster management. Some of these activities are presented in the following chapters.

Pacific Tsunami Warning Center (PTWC)[71]

Two tsunami warning centers (PTWC and WC/ATWC) have separate areas of responsibility, which are the geographical areas within which each Center has the responsibility for the dissemination of messages and the provision of interpretive information to emergency managers and other officials, news media, and the public. These are shown on the map below.

[71] Quelle: http://ptwc.weather.gov/index.php

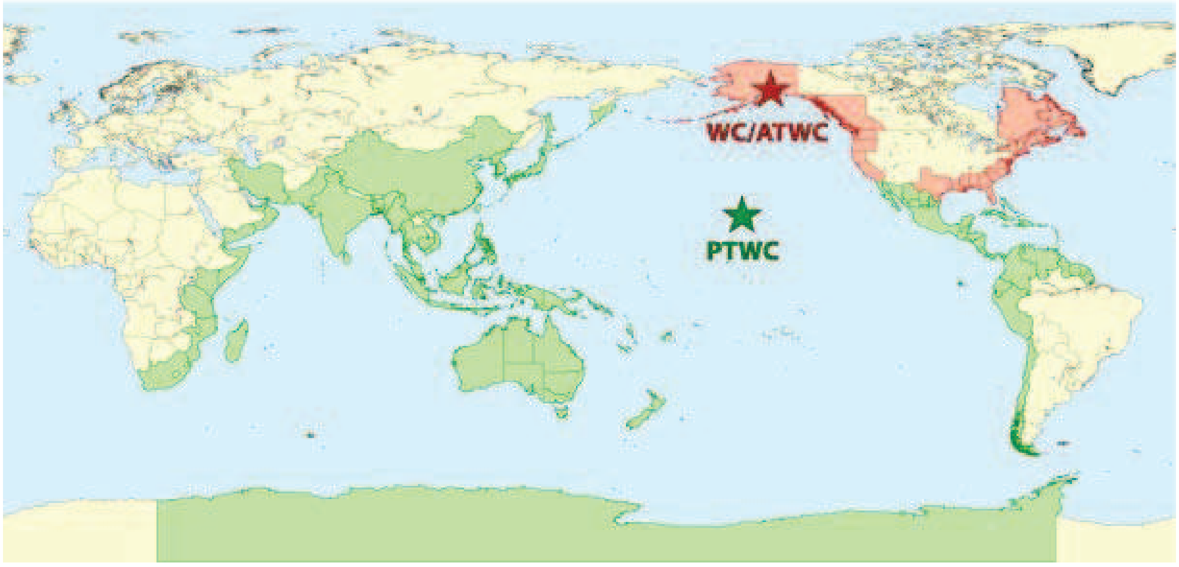


Figure 21: *Responsibilities of the tsunami warning centres in Alaska and Hawaii*

As the primary operational headquarters for the Pacific Tsunami Warning System, PTWC provides warnings for Pacific basin tele-tsunamis (tsunamis that can cause damage far away from their source) to almost every country around the Pacific rim and to most of the Pacific island states. This function is carried out under the auspices of the UNESCO/IOC International Coordination Group for the Pacific Tsunami Warning System. A few destructive tele-tsunamis are generated each century by great earthquakes around the Pacific rim. Such tsunamis can propagate across the entire Pacific in less than 24 hours, and cause widespread destruction along shorelines located thousands of miles from the source. With ever-increasing population and development along most coastlines, there is a corresponding increase in risk.

PTWC is the interim warning center to nations bordering the South China Sea (China, Macao, Hong Kong, Taiwan, Philippines, Malaysia, Brunei, Indonesia, Singapore, Thailand, Cambodia, Vietnam).

WC/ATWC is the primary warning centre for the western and eastern coasts of the United States mainland and Canada.

In the aftermath of the 1960 Chilean earthquake and tsunami which devastated Chile, killed dozens in Hawai‘ i and perhaps as many as 200 people in Japan, the nations of the Pacific decided to coordinate efforts to prevent such loss of life from ever occurring again in the Pacific Basin due to destructive ocean-crossing tsunamis. Under the auspices of the United Nations, the Intergovernmental Oceanographic Commission (IOC) established the Intergovernmental Coordination Group for the Pacific Tsunami Warning System (ICG/PTWS) in 1968. The U.S. offered the Ewa Beach center as the operational headquarters for the Pacific Tsunami Warning System, and the facility was re named the Pacific Tsunami Warning Center.

PTWC issued tsunami warnings to Alaska until 1967 when the West Coast & Alaska Tsunami Warning Center (WC/ATWC) was established in response to the 1964 Alaskan earthquake and tsunami. In 1982, the WC/ATWC area of responsibility was enlarged to include the issuing of tsunami warnings to California, Oregon, Washington, and British Columbia for potential tsunamigenic earthquakes occurring in their coastal areas. PTWC continued to issue tsunami warnings to these areas for Pacific-wide tsunamigenic sources until 1996 when that responsibility was also given to the WC/ATWC.

Following the 1975 Kalapana earthquake and tsunami on Hawai‘ i's Big Island, PTWC began issuing official tsunami warnings to the state of Hawai‘ i for local earthquakes. In 2005, PTWC similarly began issuing local tsunami warnings to Puerto Rico and the U.S. Virgin Islands, but in June 2007 that area of responsibility passed to WC/ATWC.

PTWC was re-dedicated on December 1, 2001 as the "Richard H. Hagemeyer Pacific Tsunami Warning Center" in honor of the former U.S. Tsunami Program Manager and National Weather Service Pacific Region Director who managed PTWC for many years.

In the aftermath of the 2004 Indian Ocean tsunami, PTWC has taken on additional areas of responsibility including the Indian Ocean, South China Sea, Caribbean Sea, and Puerto Rico & U.S. Virgin Islands (until June 2007). PTWC's staff size has increased from 8 to 15 as a result of the tsunami, and it now staffs the centre 24 hours a day every day.

Asian Disaster Reduction Center

The Asian Disaster Reduction Center was established in Kobe, Hyogo prefecture, in 1998, with mission to enhance disaster resilience of the member countries, to build safe communities, and to create a society where sustainable development is possible. The Center works to build disaster resilient communities and to establish networks among countries through many programs including personnel exchanges in this field.

Figure 22: *Member Countries of the Asian Disaster Reduction Center*

The activities of ADRC can be summarized as follows:

1. Provision of Information on the Latest Disasters, Disaster Preparedness of Member Countries, and Good Practices
2. Promotion of GLIDE (Global unique disaster IDEntifier)
3. Disaster Management Support System (Sentinel Asia Project)
4. Organization of International Conferences

The Sentinel Asia (SA)[72] initiative was established in 2005 as an international cooperation between space agencies and disaster management agencies, applying remote sensing and Web-GIS technology to assist disaster management in the Asia-Pacific region. A step-by-step approach for the SA implementation was adopted, and the first phase called Step 1 (2006-2007) has achieved its overall goals, demonstrating recent advancement in web-mapping technology and the ICT system. SA Step 1 has served as a good demonstrator project to share disaster-related information obtained by several Earth observation satellites on web based system including Web-GIS.

[72] Kawai, M. et al.: Sentinel ASIA – International Cooperation for Disaster Management in the Asia-Pacific- Region.

Now SA is in the second phase called Step 2 (2008-2012). SA Step 2 has applied the new ideas derived from the experience of SA Step 1 in order to broaden and strengthen the SA activities, such as the utilization of communication satellite 'Kizuna', construction of data analysis framework in the user countries, etc.

UNECE-Convention on the Transboundary Effects of Industrial Accidents

Since the early 1990s the United Nations Economic Commission for Europe (UNECE) has concentrated its efforts on preventing industrial accidents and especially their transboundary effects in its region, which stretches from Canada and the United States in the west to the Russian Federation in the east. Its work led to the adoption of the Convention on the Transboundary Effects of Industrial Accidents. It was signed by 26 UN/ECE member countries and the European Union and entered into force on 19 April 2000.[73] The Convention aims at protecting human beings and the environment against industrial accidents by preventing such accidents as far as possible, by reducing their frequency and severity and by mitigating their effects. It promotes active international cooperation between the contracting Parties, before, during and after an industrial accident.

Article 2, paragraph 1 of the convention defines the scope of application as follows:

> *Article 2. Scope*
>
> *1. This Convention shall apply to the prevention of, preparedness for and response to industrial accidents capable of causing transboundary effects,* **including the effects of such accidents caused by natural disasters***, and to international cooperation concerning mutual assistance, research and development, exchange of information and exchange of technology in the area of prevention of, preparedness for and response to industrial accidents.*

Article 12 of the convention concerns the procedure of mutual assistance in case of an industrial accident:

> *Article 12. Mutual Assistance*

1. If a Party needs assistance in the event of an industrial accident, it may ask for assistance from other Parties, indicating the scope and type of assistance required. A Party to whom a request for assistance is directed shall promptly decide and inform the requesting Party whether it is in a position to render the assistance required and indicate the scope and terms of the assistance that might be rendered.
2. The Parties concerned shall cooperate to facilitate the prompt provision of assistance agreed to under paragraph 1 of this Article, including, where appropriate, action to minimize the consequences and effects of the industrial accident, and to provide general assistance. Where Parties do not have bilateral or multilateral agreements which cover their arrangements for providing mutual assistance, the assistance shall be rendered in accordance with Annex X hereto, unless the Parties agree otherwise.

[73] www.unece.org/env/teia/about.html

Details for the implementation of article 12 are given in Annex X of the UNECE-convention

1. The overall direction, control, coordination and supervision of the assistance is the responsibility of the requesting Party. The personnel involved in the assisting operation shall act in accordance with the relevant laws of the requesting Party. The appropriate authorities of the requesting Party shall cooperate with the authority designated by the assisting Party, pursuant to Article 17, as being in charge of the immediate operational supervision of the personnel and the equipment provided by the assisting Party.
2. The requesting Party shall, to the extent of its capabilities, provide local facilities and services for the proper and effective administration of the assistance, and shall ensure the protection of personnel, equipment and materials brought into its territory by, or on behalf of, the assisting Party for such a purpose.
3. Unless otherwise agreed by the Parties concerned, assistance shall be provided at the expense of the requesting Party. The assisting Party may at any time waive wholly or partly the reimbursement of costs.
4. The requesting Party shall use its best efforts to afford to the assisting Party and persons acting on its behalf the privileges, immunities or facilities necessary for the expeditious performance of their assistance functions. The requesting Party shall not be required to apply this provision to its own nationals or permanent residents or to afford them the privileges and immunities referred to above.
5. A Party shall, at the request of the requesting or assisting Party, endeavor to facilitate the transit through its territory of duly notified personnel, equipment and property involved in the assistance to and from the requesting Party.
6. The requesting Party shall facilitate the entry into, stay in and departure from its national territory of duly notified personnel and of equipment and property involved in the assistance.
7. With regard to acts resulting directly from the assistance provided, the requesting Party shall, in respect of the death of or injury to persons, damage to or loss of property, or damage to the environment caused within its territory in the course of the provision of the assistance requested, hold harmless and indemnify the assisting Party or persons acting on its behalf and compensate them for death or injury suffered by them and for loss of or damage to equipment or other property involved in the assistance. The requesting Party shall be responsible for dealing with claims brought by third parties against the assisting Party or persons acting on its behalf.
8. The Parties concerned shall cooperate closely in order to facilitate the settlement of legal proceedings and claims which could result from assistance operations.
9. Any Party may request assistance relating to the medical treatment or the temporary relocation in the territory of another Party of persons involved in an accident.
10. The affected or requesting Party may at any time, after appropriate consultations and by notification, request the termination of assistance received or provided under this Convention. Once such a request has been made, the Parties concerned shall consult one another with a view to making arrangements for the proper termination of the assistance.

Besides this convention which includes industrial accidents explicitly the convention on the protection and use of transboundary watercourses and international lakes (1992)[74] should be mentioned in this context. In this convention "Transboundary impact" means any significant adverse effect on the environment resulting from a change in the conditions of transboundary waters caused by a human activity. Impacts on the environment can be caused for example by hazardous substances which are toxic, carcinogenic, mutagenic, teratogenic or bio-accumulative, especially when they are persistent. So this convention refers to the water quality (surface water, groundwater) but not directly to the reasons of water contamination e.g. industrial accidents.

Issues Requiring Further Discussion

1. How to improve the international co-operation in Natech prevention, preparedness and response?
2. Which role should play the OECD in that context?
3. Are there gaps/shortcomings in the international emergency assistance for Natechs?
4. Are there shortcomings in the application of the PPP in case of international assistance?
5. Which support in international assistance could offer the private sector (e.g. as a part of Responsible Care)?

[74] http://www.unece.org/fileadmin/DAM/env/water/pdf/watercon.pdf

Abstracts

Session I Natural Hazards: Risk Mapping and Warning Systems

I a Presentation 1.1- 1.2: Natural Hazard Mapping

P1.1 Hazard and Risk Maps as a Main Element of Flood Risk Management: Lessons Learnt after 2002 Flood in Saxony

SP1.1 Martin SOCHER (Saxon State Ministry of the Environment and Agriculture)

In August 2002 Germany and particularly the Free State Saxony were hit by three consecutive severe floods affecting practically two thirds of the State territory. The first flash flood originated from the Eastern Ore Mountains and caused extreme damages along five tributaries of the Elbe River including main parts of the historical city centre of Dresden. This flood was followed by a major river flood of the whole catchment area of the Mulde River with a return period between 250 and 500 years. Finally, the Elbe River coming from its headwaters in the Bohemian Mountains in the Czech Republic covered large parts of its original flood plain on both sides of the border and caused damages and losses in a hitherto unknown dimension. By the end of August 2002 it turned out that alone in Saxony 21 fatalities occurred, 25,300 houses were damaged, 200 of which were totally destroyed. In addition 7 hospitals, 236 schools, 110 kindergartens, 44 nursing homes and 18 homes of the handicapped were affected. Furthermore, the Saxon industrial base along the rivers was also seriously affected by severe damages, losses in production and shortages of supplies. The transport infrastructure was disastrously damaged as well including 750 km of roads, 540 km railway network and 180 bridges. In total the damage summed to about 6,196 Mio € not including indirect losses of the private economic sector. The water system could not withstand the mighty forces of the three floods, leading to around 18,000 individual damages at reservoirs, dykes, weirs, river soles and other hydraulic structures. During the flood the disaster management organisation got a main impact and input from the German Bundeswehr, US Troops stationed in Germany, governmental and non-governmental organisations from all over Europe. Right after the flood the Saxon Government decided to reorganise the flood protection system and related disaster management in Saxony with the following main elements.

- Reorganisation of the flood forecast system with due consideration of the single voice principle
- Establishment of Flood Protection Concepts for all main Saxon river catchments
- Establishment of Flood Hazard and Risk Maps for all areas under flood risk
- Programme of Measures for all related areas under risk

It turned out that all those elements are being addressed in the European Flood Risk Management Directive 2007/60/EC. During the severe Floods in 2006 and 2010 all those elements proofed to be important and necessary in order to cope with the actually existing flood risk. Flood Hazard and Risk Maps (HARM) have been widely distributed physically and electronically via the web to all competent authorities and to the public as well in order to use those maps during all stages of flood risk management such as prevention, protection and defence.

P1.2 Principles of Risk Management for Natural Hazards: The Case of Switzerland

SP1.2 Dr. Hans KIENHOLZ (KiNaRis, Switzerland)

Natural hazards have ever been an elementary issue in the everyday life in Switzerland. For centuries, the federal government, the cantons and the municipalities have made considerable efforts to mitigate their impact. But still, damages increased at an alarming rate.

Admittedly, absolute safety cannot be achieved, but great steps forward were made in the past few years on the road from conventional hazard protection to an integrated risk management. The latter approach is based on a balanced equilibrium of preparedness, response and recovery measures. A residual risk, which has to be defined considering social, economical and ecological criteria of well-being, must thereby be accepted. This ultimately leads to a sustainable risk management.

I b Presentation 1.3 – 1.4: Natech Risks Mapping

P1.3 Use of GIS and Conceptual Mapping in Identification and Monitoring of Natech Risks

SP1.3 Aleksandar JOVANOVIC (European Virtual Institute for Integrated Risk Management (EU-VRi)

The contribution explains an innovative concept of use of GIS (geographic systems maps) and conceptual mapping in identification and monitoring of NaTech risks and its practical application in large EU and national projects[75] respectively; respective sizes 19.3 and approx. 13 M €). The concept is based on

1. GIS maps,
2. conceptual maps (semantic analysis based),
3. stakeholders' interaction maps and
4. Influence diagrams & Bayesian networks.

These 4 main types of mapping are used for the activities related to early identification, early warning and monitoring of NaTech related risks. In all these types of maps the objects to be maps can be of a different type:

a) data about physical objects,

b) data about stakeholders and their behaviour, and

c) information (e.g. textual or graphical) about the objects and/or stakeholders.

The items in the maps can be hazards (tsunami, storms, earthquakes…), vulnerabilities (cities, infrastructures) or a combination of both (a nuclear power plant first as a vulnerability and than as a hazard). The data can be either "raw", i.e. as measured or pertinent to the very properties of the objects (e.g. quantities of dangerous materials, magnitude of earthquakes), or they can be derived data, e.g. indicators of the state of the object or its operational characteristics or calculated data (e.g. results of analyses performed such as percentage of equipment in the high risk zone or, e.g., radii of damage zones).

In the GIS the layers of data are usually those about the objects in the layers, such as capacity or age of power plants and refineries, types/categories of dangerous materials and similar. In conceptual maps, the emphasis is on the logical (contextual) vicinity of pieces of information. Natural gas fracking will in such a map be "nearer" to LNG storage plant than to, e.g., nanotechnology plant. The position and the vicinity of data in such a case are determined either on provided chunk of information only, or on the provided information combined with the ontological information (e.g. from system like GEMET[76]). For the stakeholders' maps, the most important contents are the information about the stakeholders themselves, but apart from the static information (e.g., number of stakeholders, their profiles, interests, etc.) also the dynamic information should be included (e.g. rules of their behaviour, possibly placed within the behaviour models of a given stakeholder node). In current applications in the above mentioned projects, the intelligent agent based modeling seems to be giving promising results, especially for these topics where the input of reliable data is straightforward – e.g. when the data about the stakeholders' "feelings" are easily available in large quantities (social networks, Tweet), which is often the case with data broadly discussed. The influence diagrams and the Bayesian networks are used for representing the probabilistic relationships between random variables in the NaTech risks space, e.g. between causes and consequences of risks. The data to be stored in the risk mapping systems may be observable quantities, latent variables, unknown parameters or hypotheses.

[75] the EU project iNTeg-Risk (www.integrisk.eu-vri.eu) and the German Helmholtz project ENERGY-TRANS, (http://www.helmholtz.de/en/joint_initiative_for_innovation_and_research/initiating_and_networking/helmholtz_alliances/energy_trans/

[76] http://www.eionet.europa.eu/gemet

The most innovative part of the solution proposed is the one related to "risk distances": a parameter indicating how critical is a distance between two nodes one of which is in the vulnerability data layer (e.g. a refinery) and the other one in the hazard data layer (e.g. earthquake epicentre). The risk distance, as calculated in the system, is then proportional to the magnitude of the quake and the size of the refinery, and inversely dependent on the physical distance between the object and the quake. Factors possibly contributing can be related to the physical stage of the plant (e.g. age), contextual factors and similar. The critical couples of data (selected out of usually thousands of possible couples) can be finally represented at the map, indicating the critical pairs, and that is how it is done the systems being developed based on the above concepts in iNTeg-Risk and ENERGY-TRANS project.

P1.4 RAPID-N: A Tool for Mapping Natech Risk Due to Earthquakes

SP1.4 Serkan GIRGIN (EC Joint Research Center)

Elisabeth Krausmann (EC Joint Research Center)

Natural-hazard triggered major accidents (Natechs) at industrial facilities are recognized as an emerging risk with possibly serious consequences. However, methodologies and tools to assess Natech risks are still limited in many aspects. Recent EU and OECD-wide surveys have shown that hardly any Natech risk maps exist in the Member States. Existing maps are found to be simple overlays of natural and technological hazards. A follow-up study has been performed to develop a probabilistic Natech risk mapping methodology for earthquakes and to implement it as a software tool called RAPID-N. The primary aim of RAPID-N is rapid Natech risk assessment and mapping by using fragility curves for damage estimation and simple models for consequence assessment with minimum data input. In order to facilitate the analysis, a property estimation framework was developed that can be used to calculate hazard parameters and site, process equipment, and substance properties. The framework has an expert system for selecting the most applicable estimators, based on data availability, validity conditions, and geographic location. Importing of readily available hazard maps is also supported. A basic set of fragility curves from the literature is provided for the damage assessment. If needed, custom damage states and fragility curves can be defined for different process equipment types. Conditional and probabilistic relationships can be specified between damage states and probable Natech event scenarios. The consequences of the Natech events are assessed using the Risk Management Program (RMP) methodology of the U.S. EPA and the results are presented as summary reports and interactive risk maps. RAPID-N can be used for rapid damage estimation following actual earthquakes, as well as for land-use and emergency-planning purposes by using scenario earthquakes.

SESSION II: Natech Risk Management (Including Emergency Planning) – Best Practices of Industry and Authorities

II a Presentation 2.1 – 2.5: Flood Risks

P2.1 NATECH accidents in Czech Republic: Lessons learned and Related Research

SP2.1 Pavel DANIHELKA (Technical University of Ostrava, Czech Republik)

Several NATECH type accidents happened in Czech Republic, triggered by flooding, temperature extremes or lightening. Some of them, typically in the extend of major accident, will be described and analysed from the NATECH perspective: chlorine release in Spolana Neratovice during flooding in year 2002, liquid waste tank explosion in Borsodchem Ostrava, cyanides release to Elbe river during winter 2006 or fuel tank explosion caused by cold temperature in 2011. Some other near-miss accidents or smaller accidents will be discussed as well.

Experience from accidents was evaluated by Czech Ministry of Environment, followed by recommendations and crisis planning comprising some NATECH potential events, especially in the context of potential trans-boundary accidents triggered by flooding. Between years 2007 and 2011, research project of MoE "Complex interaction between industry and environment with regard to major accidents and emergency preparedness" was realised with five cooperating research institutions and its important part was devoted to NATECH accident understanding, NATECH risks mapping and evaluation.

P2.2 The Flood 2002 – Experiences of a Hydrofluoric Acid Producing Plant

SP2.2 Christian WEISS (Fluorchemie Dohna GmbH, Germany)

The flood of the small river Müglitz and its consequences for a chemical production site will be shown in lots of pictures, made directly after the flood.

Content of this presentation as per February 2012:

1. Fluorchemie Dohna as Hydrofluoric Acid Producer (as a short introduction)
2. Hydrofluoric Acid – a very toxic and corrosive substance (as a short introduction)
3. Precautionary provisions of Fluorchemie Dohna for external influences on a safe production
    a) Safety for people inside and around the site
    b) Safety for production units on site
    c) Safety for railcars on site and off site
    d) Safety for infrastructure
4. Experiences during the flood of the river Müglitz – Answers of the questions:
    a) Did all precautions fulfill the needs?
    b) What did happen and how was it solved?
    c) Could a flood like this be expected?
5. Consequences and resulting reconstructions for the future

- New precautions against a new flood

P2.3 French Regulation for Integration of Natural Hazards in Industrial Safety Assessment – Choice of Reference Scenarios to Characterize these Natural Phenomena

SP2.3 Cédric BOURILLET,

Xavier STREBELLE (French Ministry of Ecology, Sustainable Development, Transports and Housing)

French regulation requires the consideration of natural hazards in the industrial safety assessment (in safety report), as well as other internal (technical failure, human error) or external (domino effects between nearby installations...) initiating events, as long as it induces the occurrence of major accidents.

The integration of these natural hazards is based on reference scenarios.

Natural events whose intensity is higher than the reference phenomenon may be excluded from the safety report (Order of May 10, 2000).

For the natural reference events, it is necessary to demonstrate the strict compliance for their corresponding regulation in the safety report (Circular of May 10, 2010). This is particularly true for earthquake, lightning, flooding, snow and wind, for which national specific regulation or good practices for hazardous industrial facilities exist. In these cases, if the rules are observed in the plant, the process of risk reduction at source is considered sufficient (deterministic approach). The probability of occurrence of the natural event is not evaluated and is not integrated in the calculation of probability of occurrence of associated major accidents (criterion used with severity to assess acceptability and make land-use planning decisions). The natural event should be treated by emergency plans.

For other natural hazards not listed above, such as avalanche, volcanic eruption..., there are no national specific regulations or best practices to their consideration. In these cases, the integration of these natural phenomena in the safety report is left to the discretion of the operator.

This approach brings up the question of the choice of natural phenomena to take as a reference. Should we consider realistic reference events (which happen often) or extreme events (based on what has already seen worse in the past, and increased to take into account events of even higher intensity, the climate change...)? What happens if a major accident occurs in an adequately dimensioned installation (regarding the natural phenomena taken in reference), because of intensity of natural aggression higher than imposed? What is the responsibility of authorities? of industry? The point of view of France on these questions will be exposed.

P2.4 Methodology for Integration of Flood Hazard in Industrial Safety Assessment

SP2.4 Agnes VALLEE (Institute on Industrial Risk – INERIS, France)

International databases such as OFDA and CRED show that floods accounted for more than half of disasters registered for the 1990-2001 period. With consequences of climate change largely unpredictable at local level, future statistics are not likely to show any improvement. As human activities historically developed in river areas and floodplains, industrial facilities are structurally exposed to flooding. Past events witnessed industrial vulnerability to flooding, including direct impact on structure; loss of safety measures; loss of utilities; business interruption etc.

In response to such natural-technological interaction, mitigation efforts have taken two main directions: land-use planning in flood-prone areas; vulnerability reduction in flood-prone facilities. This communication focuses on the former issue and presents good practice accumulated in France for the mitigation of flood impacts on industrial facilities.

To address this issue, INERIS proposes to present a methodology for the integration of flood hazard in risk-reduction process for industrial plants is proposed by INERIS. Both floods originated from a dam rupture and unusual rainfalls will be considered.

This methodology follows a sequence in 4 steps.

- The first step aims at determining whether the studied plant is located in a floodable area or not. If it is the case, data are needed to better understand the flooding, such as type of flooding, water height, flow velocity, speed of water level rising, flooding duration, return period of flood…
- Based on information gathered in step 1, the topography of the industrial plant, the location of buildings and facilities within plant perimeter, areas which could be affected by flooding are identified. In the potentially flooded areas, facilities and equipments that could cause major technological accidents are identified. A systematic risk analysis is then performed for each of these equipments. The accidental sequences leading to dangerous phenomena (fire, explosion, toxic cloud dispersion, pollution…) are detailed, and existing safety barriers are highlighted.
- The safety barriers are analyzed more in details in terms or performance (efficiency, maintainability, testability…). Each barrier shall be assessed also in terms of kinetics, depending on implementation time, availability of human resources, technical devices… Depending of the available time before the arrival of water and resources in case of flooding, some safety barriers are also selected for risk assessment and emergency plan.
- A final analysis should assess if all barriers can be implemented at the same time, taking into account the available personal and the available time between the information of flood threat and the flood itself.

A suggestion of possible safety barriers against flood will be made by INERIS.

Finally, the communication will discuss the experience gained by INERIS after implementation of this method to a SEVESO low-tier industrial site in France.

P2.5 The German Technical Rule for Process Safety: Prevention and Preparedness due to Hazards by Precipitation and Floods.

SP2.5 Karl-Erich KOEPPKE (Dr. Köppke GmbH, Germany)

In 2002 the east and south of Germany suffered due to a severe flood in summer. This flood caused loss of live and severe damage but also threatened several establishments according to the Seveso-Directive. One consequence of a research project for the Umweltbundesamt was, that the Technical Rules for installations and equipment did insufficient consider risks by natural hazards. Therefore the Umweltbundesamt issued a project to develop a draft for a Technical Rule on hazards due to precipitation and floods. This draft was further elaborated by the German Commission on Process Safety, tested by application on an establishment, passed the public hearing and the hearing of the Länder and is now officially published in the Federal Bulletin.

The scope, the methodological approach and the requirements of this Technical Rule shall be presented. Especially the proposed link between identification and analysis of natural hazards on one hand and methodological process safety analysis and risk management on the other hand shall be explained. Finally the presentation shall explain how this Technical Rule considers the possible increase of hazards by precipitation and floods due to expected climate change.

II b Presentation 2.6 – 2.9: Earthquake Risks

P2.6 Natech Accidents due to the 11 March 2011 Earthquake and Tsunami and Follow up

SP2.6 Yuji WADA (National Institute of Advanced Industrial Science and Technology (AIST), Japan)

The Great East Japan Earthquake had hit eastern Japan at 14:46, on March 11th, 2011. The Maximum magnitude was reported 9.0, at 130 km from east coast. The locations of earthquakes were about 200 km from east to west and about 500 km from north to south.

After the first great earthquake, the series of big aftershocks have followed and even only on a day, the number of aftershocks greater than magnitude 5 was 74, on March 11th. The next day, the number was reported as 99, and even now aftershocks have kept hitting Japanese land.

Even the earthquake itself was big enough to shake Japan, it was caused by another disaster, a Tsunami. The earthquake center was on the coast of Tohoku area, the north part of Japan, however, the Tsunami was observed everywhere in Japan.

The maximum height of the Tsunami was reported as 10-15 m, and the run up heights which the Tsunami went up along the slope were around 40 m at many points. Especially, Tsunami had struck severely the huge area of eastern Japan, and 561 km^2 of the area were inundated on the day.

And currently, the total number of fatality because of the earthquake and Tsunami are 15,845. Even after one year has passed, still 3,375 have remained missing.

After this great earthquake, some surveys have been done at the chemical plants to figure out the damage of the earthquake, Industrial Safety Division of NISA, METI, has done one of the surveys.

Another survey has been done at a chemical plant in Tohoku area to study the effect of earthquake vibration, liquefaction phenomena, etc., on the damage of the plant by the Japan Society of Safety Science.

The results of these surveys will be presented.

P2.7 Lessons from the Sendai Industrial Complex and Chiba's Cosmo Oil Refinery Fires Following the Great Eastern Japan Earthquake and Tsunami.

SP2.7 Ana Maria CRUZ NARANJO (Consultant, Université de Bordeaux I)

KRAUSMANN, E.; IKEDA, N.; KAJITANI, Y. and TATANO, H.

This presentation concerns two case studies from an on-going study of impacts of the Great Eastern Japan earthquake and tsunami of 11 March 2011 on industry in Miyagi, Ibaraki and Chiba Prefectures in Japan. The study involved a series of field trips to the affected areas, and interviews and visits with government officials. The purpose of the study is to assess the performance of industrial risk management practices and emergency response to the Natech accidents that occurred.

The earthquake of magnitude 9.0 occurred off the Pacific coast of Tohoku, Japan, on March 11, 2011, at 14:46 Japan Standard Time (5:46:23 UTC). The rupture area, which was approximately 450 km ✢ 200 km, generated a tsunami 130 km off the coast of Miyagi Prefecture, northeast Japan. The tsunami inundated over 400 km✢ of land. As of 26 October 2011 the number of deaths was 15,829, the number of injured was 5,943, and the number of missing was 3,725 (Japan National Police Agency). The earthquake and tsunami caused complete or partial collapse of more than 300,000 houses. The earthquake and tsunami had a significant impact on industry, and in particular on petrochemical and chemical industry in the affected areas, resulting in hazardous-materials releases, fires and explosions with impacts on neighbouring communities, and leading to business interruption. The natural disasters led to economic impacts and supply-chain disruption due to the damage of production facilities or shortage of raw materials. The direct losses amount to more than 200 billion US dollars (not considering the Fukushima nuclear power plant accident). Although the earthquake produced strong ground motion, most damage was caused by the tsunami and not the earthquake. This highlights the effectiveness of Japan's earthquake damage reduction measures in saving lives and property.

This paper presents the results of the Natech accident investigations at two sites: the JX Refinery and neighbouring facilities at the Sendai industrial complex (Miyagi Prefecture), and the Cosmo Oil Refinery and industrial complex in Chiba (Chiba Prefecture). Both sites suffered which suffered multiple fires, hazardous materials releases and oils spills affecting several facilities and required several days to contain. For each case study the paper presents the various event trees and failure mechanisms leading to the multiple fires and hazardous materials releases, and analyses the risk management and emergency response to the accidents. Finally, the paper presents some preliminary lessons learned and recommendations on good (and bad) practices of industry and public authorities.

P2.8 The Natech Events During the 17 August 1999 Kocaeli Earthquake: Aftermath and Lessons Learned

SP2.8 Serkan GIRGIN (EC Joint Research Center)

Natural-hazard triggered technological accidents (Natechs) at industrial facilities have been recognized as an emerging risk. Adequate preparedness, proper emergency planning, and effective response are crucial for the prevention of Natechs and mitigation of the consequences. Under the conditions of a natural disaster, the limited resources, the possible unavailability of mitigation measures, and the lack of adequate communication complicate the management of Natechs. The analysis of past Natechs is crucial for learning lessons and for preventing or preparing for future Natechs.

The 17 August 1999, Kocaeli earthquake, which was a devastating disaster hitting one of the most industrialized regions of Turkey, offers opportunities in this respect. Among many Natechs that occurred due to the earthquake, the massive fire at the TUPRAS Izmit refinery and the acrylonitrile spill at the AKSA acrylic fiber production plant were especially important and highlight problems in the consideration of Natechs in emergency planning, response to industrial emergencies during natural hazards, and information to the public during and following the incidents. The fire at the refinery lasted for 5 days and could only be extinguished by international support. The spill of 6500 t of acrylonitrile (AN), a toxic substance, damaged domestic animals, affected agricultural activities, endangered public health, and resulted in environmental pollution that required 5 years of continuous treatment for reclamation. Both events required the evacuation of the settlements in the vicinity of the facilities and hampered search and rescue operations. There were also considerable economical losses.

Despite their adverse consequences, these Natech events and their aftermath provide valuable information and lessons for Natech risk management and shed light on what should and should not be done in case of such emergencies. The analysis of these events shows that even the largest and seemingly well-prepared facilities can be vulnerable to Natechs if risks are not considered adequately. In the presentation, first a detailed description of the events will be given to emphasize what went wrong, and then the recovery, restoration and remediation work completed during the past decade will be reported. Moreover, weaknesses in response to and management of the events will be discussed and recommendations will be made for better Natech risk management. The presented lessons learned from the case studies can be useful, not only for Turkey but also for other Natech-prone countries.

P2.09 New French Seismic Regulation for Hazardous Industrial Facilities

SP2.09 Adrien WILLOT,

Agnes VALLEE (Institute on Industrial Risk – INERIS, France)

A new regulation (Decrees 210-1254 and 2010-1255, dated October 22nd 2010) recently introduced a new zoning for seismic activity, dividing France into 5 areas, from areas 1 (very low seismic activity) to 5 (high activity).

This regulatory change comes from the authorities whose policy is to continuously improve the safety of citizens against seismic risk. Indeed, the previous zoning, valid since 1991, was based on studies performed in 1986. The development of scientific knowledge has led to a re-evaluation of seismic hazard and a re-definition of the zoning based on a probabilistic approach (taking into account the return periods).

In this context, the presentation of INERIS will focus on how this new zoning has to be considered in hazardous industrial facilities.

The industrial facilities in France are classified according to the properties of the handled/stored chemical products or according to their activities. We name these installations "classified sites".

With regards to the regulation which establishes the rules for protection against earthquake, the classified sites may be subject to regulation applicable to "normal risk" or "special risk" installations.

According to the Ministerial Order of 24 January 2011, "special risk" classified sites are pieces of equipment in low and upper-tier SEVESO establishments that may lead, in case of an earthquake, to one or more dangerous phenomena with lethal effects out of the site boundaries, unless there are no permanent human presence in this identified lethal effects area.

The elastic response spectra (vertical and horizontal) in acceleration, representing the seismic movement of one point in the surface on the right of the establishment are then elaborated, using information given in the Ministerial Order.

If the installation is new, compliance to regulation must be demonstrated when the operator submits a request for a permit to operate. Protective measures against the earthquake must then be implemented at the start of operations.

For existing establishments, a study to assess the technical measures necessary to protect from earthquakes must be carried out before December 31st 2015, and the implementation of these measures must not exceed 1st January 2021.

All other pieces of equipment in establishments that do not belong to the "special risk" category are considered as "normal risk" category. In this case, classified sites must apply the Order of 22 October 2010 like all buildings on French territory. There are rules for new buildings, or existing buildings in specific conditions, in seismic area 2, 3, 4 and 5. The application of Eurocode 8 is required, while leaving the possibility of using standard rules in the case of simple structures. The protection level is adjusted according to the structure involved.

The presentation will also bring lessons learned from the INERIS / Ministry scientific mission in Japan at the end of November 2011 (impacts of the earthquake and tsunami on industrial facilities), in particular the recommendations on the protection of establishments from earthquakes.

II c Presentation 2.10: Other Hazards

P2.10 Seveso Directive Plants Threatened by Bush Fires: Analysis on Several Reported Cases and Guidelines Proposal

SP2.10 Jean-Paul MONET (French Fire and Emergency Management Service)

F. VAUCOULEUR, R. AUBRUN (Bouches-du-Rhône Departmental Fire and Emergency Brigade)

In Mediterranean areas, main concern of natural risk is forest and bushfire. Since many years these accidents threaten high risks plants (e.g. radioactive power plants, high risk industrial plants or trading estates).

In 1989, an experimental nuclear site was slightly damaged by a forest fire.

In the last 5 years, more than 6 cases have been reported, introducing a "new deal", in the art of fire fighting and in the preparedness of the 45 Seveso classified plants of this French departmental territorial division.iuh

At first, the integration of these new scenarios in the safety report is on the road.

Secondly, the fire service has listed some guidance, in order to give new procedures to the industrial plants involved.

At last, during the 2011-2012 winter, the fire service use the prescribed fire tool to decrease the biomass quantity, in the nearby area around some petrochemical plants.

II d Presentation 2.11 – 2.14: Methodology

P2.11 Proposal of Methodology for Combined Natural and Technological Risks Identification and Assessment.

SP2.11 Pavel DOBEŠ (Technical University of Ostrava, Czech Republic)

One from important problems in the major accident prevention and preparedness are the combined natural and technological risks, often in the form of technological accidents triggered by natural phenomena. The goal of presented work was to propose the methodology applicable to assessment of such events.

Flow of energy, material and information are the principle of mutual interactions among different types of risks occurring at major accidents. According to complexity of real phenomena during these unwanted situations, many combined natural and technological risks could be identified. Large effort and energy were spent on solving of the problem of combined risk assessment, including the series of case studies on different types of various risks combinations around the world. Production of lessons learned also must not be neglected.

Combined risks represent different level of threat for human, property and often also for various compartments of the environment. In the contrary to combined risks, for the occurrence prediction and effect estimation of single risks, many methodologies and models are available and presented work. Proposed methodology aims to establish basis for identification and assessment of certain combined risks, including so called „NATECH" risks. During development of methodology, combined risks were studied on historical events by means of several approaches.

Proposed methodology is divided into 10 separated steps, which are furthermore briefly mentioned: defining the purpose and scope of analysis + gathering multidisciplinary oriented team; identification and selection of risks in the area; analysis of simple risks; assessment of single risks in relation to vulnerable targets; identification of possible interactions between selected risks including links on vulnerable targets; description of possible scenarios of combined risks; the assessment of combined risks; decision step with question was selected all relevant risks and their combinations; management of inacceptable risks in relation with vulnerable targets; periodic update and revision of the study. Links to related information resources and recommendations of applicable methods for each step are included. Proposal of methodology is oriented mainly on vulnerabilities in the potentially evaluated areas. In the methodology were integrated several approaches and experiences developed mainly in European region in past decade.

Application of proposed methodology assumes the organization of multidisciplinary oriented team of experts, according to selected combination of natural and technological risks. In the frame of specific application, experts have the high degree of freedom in the choice of analytical approaches for single risk.

P2.12 A Bow-tie for Natech: Approaching the Quantitative Assessment of Risk Associated to Natech Scenarios.

SP2.12 Valerio COZZANI (University of Bologna, Italy)

The increasing frequency of some natural events having a particularly high severity raised a growing concern for the integrity of critical industrial infrastructures and for the consequences of technological accidents that may be triggered by severe natural events.

The specific features of technological accidents triggered by natural events were recognized only rather recently, and these scenarios are now indicated as NaTech accidents. The screening of past accident databases points out that NaTech accidents are quite common in industrial facilities. However, these scenarios are seldom considered in the safety assessment of industrial facilities and a specific evaluation of the potential consequences of NaTech accidents is generally not carried out. In the present contribution, the specific features of NaTech scenarios will be evidenced, also discussing the results of past accident analysis. A possible framework for the quantitative assessment of NaTech scenarios will be defined and recent advances in the tools available for the quantitative analysis of risk associated to NaTech events will be presented. A specific insight will be given on fragility models for industrial equipment. Possible integrations with current practices adopted for technological risk management of industrial sites will be discussed.

P2.13 The Challenge of Making 'Typical and Atypical' Major Hazard Szenarios in the Chemical Industry

SP2.13 Richard GOWLAND (European Process Safety Center)

Major Hazard scenarios in the Chemical and Oil and Gas Industries must be identified and assessed as part of the corporate and legal and requirements for operation. The record shows that the industries and Competent Authorities have not always been able to predict or agree on a complete portfolio of these risks. These might be characterised as 'unknown unknowns'. It can be argued that we need to find better ways of predicting these more effectively, communicating them in a transparent manner and finding ways to prevent or mitigate them. It is also apparent that some predictable events have been characterised as not realistic or where probability and frequency data were missing and therefore protection has not been seriously considered.

Natech hazards can be said to fall into this category, since they might appear to be random. Traditional hazard identification methods such as Hazard and Operability study have served us well, but we should be considering how we can add to or enhance these. The European Process Safety Centre has a group which studied 'Atypical Scenarios' and has set out good practice for how this might be achieved. An approach which sets out all potential worst cases including those caused by Natech events and goes on to define causes and possible avoidance or protection strategies is evolving.

This includes the application of Layer of Protection Analysis (LOPA) to a wider range of scenarios. The combination of a creative approach to finding and characterising Natech hazards with simple risk assessment such as LOPA has potential to allow better decision making. The paper shares this progress and suggests practical ways of achieving a safer world.

P2.14 Lessons Learnt from Natural Disasters

SP2.14 Charles COWLEY (Center for Chemical Process Safety, USA)

Lessons Learnt from Natural Disasters, CCPS 2006:

Natural disasters over the last few years have tested preparedness and response plans of the chemical and petrochemical industries on or near the Gulf coast. Although responses were generally well managed and as efficient as conditions allowed, there is always room for improvement. In these cases, experience is often the best teacher, but everyone should not have to experience the same thing to learn from it. AIChE's Center for Chemical Process Safety (CCPS) member companies believe that sharing experiences and learning from others are effective and efficient ways of improving performance and reducing risk.

With that goal in mind this pamphlet, funded by the generous support of the United Engineering Foundation, pulls together, analyzes, and presents in a "how to use" format the recent experiences and successes of various CCPS member companies, their "Lessons Learned," and advice on how to prepare for and recover from a natural disaster. Most of this information comes from workshops in 2006, with the April workshop and the June teleconference as the focal events. Members of the CCPS Technical Steering Committee who participated in the June teleconference, Scott Berger—CCPS Director, Karen Person—CCPS Project Engineer, Karen Tancredi—Dupont, and Adrian Sepeda—CCPS Staff Consultant, are recognized for the role they played in bringing this project to fruition. This pamphlet merely "suggests" and in no way sets a standard or expectation for performance or actions. In the end, it is the responsibility of each company and its employees to act on their beliefs and available information to secure their site, protect their employees, and protect the community.

This pamphlet takes a risk based approach in addressing the chronological phases of dealing with a natural disaster—preplanning, just before the disaster strikes, during the disaster, and after the disaster recovery. The appendices provide check lists and examples that should be customized to suit your specific situation and company culture.

The CCPS chemical and petrochemical company members are well grounded in using risk evaluations as a tool to run their businesses safely. This paper uses that same risk evaluative approach in preparing for and recovering from a natural disaster. Each phase of the preparation and recovery should be evaluated for risks considering both probabilities and consequences. By doing so, actions can be preplanned, prioritized, properly scheduled, and evaluated for effectiveness and impact. Risk assessments should be made for two broad categories:

- the risk that a natural disaster imposes on the safety and security of your facility, its contents, equipment, chemicals, market share, and personnel; and
- the risk that your facility (while being impacted by a natural disaster) imposes on the surrounding community, ecosystem, and personnel.

These risk evaluations facilitate understanding of appropriate actions to take, when to take them, and required communications.

SESSION III: Consideration of Climate Change in Natech Risk Management

P3.1 New Results on Extreme Events

SP3.1 Udo Mellentin / Wilfried KUECHLER (Saxon Agency for Environment, Agriculture and Geology)

Climate change has altered the intensity, frequency, and geographic extent of some types of extreme events and is expected to continue to increase in the future. At present we see a regional variation in temperature changes; increases are higher over land and in the northern hemisphere. It is only through the careful study of the pattern of events over years or decades that we can begin now to attribute the changing pattern of our weather and the weather extremes to climate change. For the time being, until humanity brings its greenhouse gas emissions under control, we can expect each decade to be warmer than the preceding one.

Even in the presence of the existing warming trend, natural climate variability can lead to more or fewer cold outbreaks in a given season and region. Coupling of natural climate modes can change the climate state for years including prolonged warming and cooling. Unfortunately, it is common for the public opinion to take the most recent local seasonal temperature anomaly as indicative of long-term climate trends.

The frequency of extreme warm anomalies increases disproportionately as global temperature rises. Some examples will be shown and should demonstrate the new quality of some extreme events (new temperature records for month, season and year after the millennium) not at least because of "Warming-Background" in many parts of the world and the coupling of changing circulation patterns to temperature and precipitation extreme events in Europe. So, in summer 2003 and July 2006 Western Europe and July 2010 Eastern Europe (Russia), respectively, suffered unusual extreme heat waves and dry spells. Heat waves in particular show a high probability of worsening over most land areas in upcoming years due to rising global air temperatures.

Future trends in cyclone activity and tornadoes were more difficult to assess due to limitations in monitoring records and climate forecasting models. Moreover, global warming is projected to intensify the hydrological cycle and increase the magnitude and frequency of intense precipitation and river flood events in many parts of the world. First significant changes in this direction are already clearly to be seen and will be discussed.

P3.2 Adaptation Measures of the Oil and Gas Industry

SP3.2 Dr. Ana Maria CRUZ NARANAJO (Consultant, Université de Bordeaux I)

Elisabeth KRAUSMANN (EC Joint Research Center)

In this presentation we assess the vulnerability of the oil and gas industry to climate change, and discuss available options for mitigation and adaption. Current and future analytical frameworks are presented and their limitations discussed. Furthermore, the paper discusses other factors that will play a major role in the ability and/or willingness of the oil and gas industry to mitigate and/or adapt to climate change. Overall, the paper concludes that climate change and extreme weather events represent a real physical threat to this industrial sector, particularly infrastructure located in low-lying coastal areas, and areas exposed to extreme weather events. The oil and gas industry will have to identify high risk areas, assess its vulnerability to climate change and take appropriate measures to prevent or mitigate any potential negative effects.

P3.3 Engagement of BASF in Adaptation to Climate Change

SP3.3 Monika BAER (BASF AG)

The evaluation of the physical risks from climate change is part of our extensive risk management in our global Competence Centre Responsible Care. The Competence Centre Responsible Care is part of our global Competence Centre Environment, Health and Safety. Our international in-company BASF climate monitoring expert group is observing local climate changes at the 28 most important production sites of the BASF Group in the four regions Europe, Asia, North and South America. Temperature changes, changes in precipitation quantities, and extreme weather events are observed and recorded. The results of published regional climate modeling studies are analyzed and compared with the trends identified internally. We cooperate with research institutes and internationally recognized institutions to interpret the modeling studies and thus be able to better assess the extent to which we could be affected. On a yearly basis recommendations for action are derived from identified physical risks for BASF locations. As the climate variables have an average period of approximately 30 years, tracking climate change and its effect on BASF sites is a continuous process that will remain in force over the coming decades and beyond. Most of the identified risks will materialize within a timescale of more than 20 years. Also, the assessment of physical risks from climate change currently includes very high uncertainties, since accurate regional climate change models with high resolution are not yet available.. In a nutshell, management of the identified risks in many cases rather implies deepening of the understanding of the exact extent and time-frame of the risk than physical action. The consequent monitoring of climate change enables us to adapt gradually, partly within the framework of regular investment cycles and thus reduce additional investment.

In regard to the risk of extreme weather events like hurricanes and flooding and the induced changes in the supply chain, we already see the consequences of climate change and have taken the appropriate actions as reported below.

i) Changes in precipitation patterns change the water availability for cooling purposes or the run-off in rivers that serve as important transportation pathway. In Europe, for example, 34% of goods (incoming and outgoing) are transported by ships on rivers to and from our production sites. Worldwide in 2010 we used 2 billion cubic meters of water, 88% for cooling purposes and 12% for various other production purposes. 95% of the total water supply is taken from surface water.

ii) Changed availability of water therefore requires adaptation of the cooling equipment of our plants. Changes in the discharge of rivers therefore will require us to adapt our logistic concepts accordingly. Also heightening of dams is regarded and carried out where reasonable.

iii) To avoid sites being flooded in the future, some smaller adaptations such a heightening of dams have been and will continuously be carried out at the relevant locations. These adaptation measures are mostly carried out as part of regular maintenance work. Adaptation to a reduced usability of rivers for transportation is possible and is already practiced nowadays in case of low water levels in the river Rhine.

P3.4 National Grid's Climate Change Adaptation Journey

SP3.4 Gary THORNTON (National Grid, UK)

National Grid supports the views of Climate Change science and believes that mankind contributes to a level of climatic change. National Grid also recognises that meeting the challenges of climate change is not only about reducing greenhouse gas emissions and developing a low-carbon economy but also ensuring that National Grid adapts to climate change such as; incremental hotter drier summers, warmer and wetter winters, coastal and river bed erosion and increasingly frequent extreme weather events such as floods.

National Grid is at a very advanced stage of embedding its Climate Change policy for both mitigation and adaptation within the organisation, with climate change risks firmly embedded into National Grid's Risk Management Procedure which is constantly reviewed and updated with appropriate actions and targets.

Analysis and experience has shown that energy infrastructure may be vulnerable to certain aspects of climate change; however the infrastructure has a significant degree of resilience to change, and therefore adaptation. In addition, technically it will be feasible to deal with adaptation issues over short, medium and long-term periods.

In order to ensure National Grid is prepared for the affects of climate change, it is engaged, in conjunction with other UK energy companies and the scientific community focussing on mitigation and adaptation to climate change.

Key vulnerabilities in the energy sector are those associated with higher temperatures and an increased intensity of precipitation and therefore flooding. Other possible vulnerabilities may include changes in wind, increased frequency of lightning etc.

This presentation will outline National Grid's adaptation story from the start of our adaptation work in 2006 through to the present day and beyond briefly discussing our future research within this field.

SESSION IV: Application of the Polluter-Pays-Principle (PPP) to Natechs

P4.1 Polluter-Pays-Principle, Tort Law, Natural Catastrophes and Liability Insurance

SP4.1 Christian LAHNSTEIN (Munich Re, Germany)

Environmental law: Multiple instruments realize the polluter pays-principle in environmental (public and private) law and policy. One of them is tort law.

Tort law: There are misunderstandings about the relationship between natural catastrophes, tort law and insurance. Under negligence rules, concepts like "Act of God" are irrelevant. Causes of catastrophes may be unforeseeable or unavoidable, but not necessarily their harmful consequences. In addition, in many countries exist general rules and also in most countries a historical patchwork of specific national and international rules which impose strict liability, independent of negligence, mostly based on the specific danger of certain activities. Here, "Act of God" can be a decisive defence, but not necessarily. It can be argued that natural catastrophes just realize the specific danger of a specific activity, on which strict liability is based. And there is an open debate about sense and nonsense of liability caps in many of these specific laws.

Liability insurance: As most natural catastrophes are accidents, there is full liability insurance cover, independent of whether the catastrophe is considered as "environmental" or not necessarily. But frequently there is poor insurance penetration (see the 2,000 € liability insurance limit in a Hungarian accident). Finally, there are misunderstandings about the relationship between liability caps and liability insurance limits.

P4.2 Role of Insurance When the Polluter Pays

SP4.2 Judith GOLOVA (MARSH Insurers, UK)

BACKGROUND

The environmental impacts of a chemical accident initiated by a natural disaster are well understood. For example, an earthquake can cause an oil spill from a tank storage which in turn results in soil and groundwater contamination.

Once the Polluter Pays principle has been firmly established into national law, and a polluter has been identified after a natural hazard event, one would expect that the polluter would start paying out for claims for bodily injury and property damage, and would start cleaning up the soil and water resources once it is safe to do so.

The reality is often disappointing. This is not because the polluter is unwilling to take responsibility to correct for the damage that has been done. It is because natural hazards often result in such severe damage that the polluter finds himself lacking the financial resources to respond.

This is where insurance needs to step in. Industry often prioritises to buy insurance for those risks that are easily foreseeable. Purchasing motor insurance for example is never disputed because everybody is aware of the risks of driving. Where risks and liabilities become more unforeseeable and rare, such as pollution events, insurance is often regarded to be only for those who can afford it, or for whom public pressure encourages it.

ENVIRONMENTAL IMPAIRMENT LIABILITY INSURANCE

When asked about how prepared an industrial operator is to respond to pollution, the false assumption is often that they already have pollution cover in their existing insurances. However, Public Liability policies will not typically provide any meaningful cover for any cleanup that is required by the regulator or environment agency rather than a third party. Furthermore, Public Liability policies will not respond to cleanup on the industrial site itself. Lastly, Public Liability policies will not respond to biodiversity damage.

The Environmental Impairment Liability insurance market has developed significantly and is able to provide effective risk transfer solutions for operational and/or historic pollution and environmental damage risks. This can be structured to cover on-site and off-site legal liabilities arising from pollution/contamination on, at, under or emanating from an insured site. Policy wordings do not exclude natural hazards and there is usually no need to establish that the insured was at fault.

CONCLUSION

Regulators should encourage the uptake of specialist Environmental Impairment Liability insurance. This will allow industry to be more resilient to natural hazards, some of the effects of which cannot be foreseen or managed using engineering controls.

SESSION V: International Co-operation on Natech Risk Management

V a Presentation 5.1 – 5.3: International Projects

P5.1 Needs Assessment Study on Chemical Accidents Prevention and Preparedness in Region 8, Phillippines

SP5.1 Jean C. BORROMEO (Philippine Department of Environment and Natural Resources)

It has already been recognised that in developing countries, the effects of natural disasters often impact upon vulnerable communities which do not have sufficient resilience to prepare for, mitigate and recover from such events. The impact of a natural disaster on a facility handling hazardous substances in the vicinity of these communities can therefore have devastating effects on an already exposed population.

This "Needs Assessment Study" was conducted as part of the German International Cooperation's (GIZ) Disaster Risk Management Project in Eastern Visayas (Region 8) of the Philippines. Details on the quantity, character and location of hazardous substances in industrial facilities in the area, as well as the necessary precautions with respect to chemical accident management, were identified and served as the basis for identifying capacity building needs of the Region in order to strengthen its chemical accident risk management capability.

The Study is based on desk top research and on-site visits to a selection of facilities handling hazardous chemicals in the Eastern Visayas Region which took place between 28th July and 5th August 2010. The chemical facilities considered were those with substantial quantities of hazardous chemicals and ranged from ice manufacturing plant through fuel terminals to large scale chemical processing of the fertilizer and the copper smelting and refining industries. Household chemicals, e.g. cleaning agents and small scale commercial activities, e.g. gasoline filling stations, hardware stores, engine cleaning activities, LPG dealerships, were excluded from the study. The study area covers the Eastern Visayas Region, however there is little industry of significant size handling hazardous chemicals outside of the Province of Leyte.

Notable among the findings of the study were that while the identity of the hazardous chemicals in use in the facilities visited is generally correctly given, the quantities of these chemicals at any given time are unknown. Moreover, the use of GHS classification and labeling is generally only applied if this is the system adopted by the chemical supplier and systematic hazard identification and risk assessment is carried out only in a very few cases. Further, while some general awareness of which natural hazards affect the Region of Eastern Visayas exists, there is little awareness of specific potential effects on individual facilities and installations unless this has been identified as a high operational risk. There is often a lack of awareness of the need for emergency planning and thus a lack of communication with emergency responders or the local community. Some facilities do have good hazardous chemical management practices in place and a strong CSR program with links to the community and fire departments but there is a large gap between the most developed practices and those of simpler facilities.

Based on these findings, a range of recommendations were made towards capacity building of the local and regional authorities in the field of process safety using existing industry networks to share best practice and to establish "codes of practice" for particular activities such as chlorine water treatment or ammonia refrigeration systems. In addition, it was recommended to use local knowledge to develop chemical hazard maps at the Barangay level so that response planning, land-use planning and natural disaster preparedness are able to have a more informed decision making process.

P5.2 Apell Process in Sri Lanka: Preparation of Integrated Emergency Preparedness Plans for Two Selected Industrial Zones

SP5.2 Jayavilal FERNANDO (Central Environmental Authority, Sri Lanka)

In the aftermath of Tsunami catastrophe in December 2004 the United Nations Environment Programme (UNEP) through the Ministry of Environment (MOE) came forward to offer assistance to the Government of Sri Lanka to implement a programme on 'Awareness and Preparedness for Emergencies at Local Level' (APELL) in Sri Lanka.

Accordingly, it was decided to implement a project at two pilot locations viz; the Koggala Export Processing Zone (KEPZ) and the Ekala Industrial Estate (EIE) which were likely to face natural and industrial hazards. The French Ministry of Ecology and Sustainable Development, France provided the necessary funding for the implementation. The Central Environmental Authority (CEA) of the MOE was designated as the implementing body.

The APELL project in Sri Lanka had two aims

1. to build the capacity and raise the awareness of national authorities and local level institutions on how to better prevent and prepare for disasters and
2. to support the implementation of an APELL demonstration in KEPZ, Koggala and the Industrial Zone in Ekala with the effective participation of representatives of the industrial community, the local level government institutions and the local community.

The ultimate goal of the APELL project is to reduce disaster vulnerability and enhance the ability of the national and local level institutions and the private sector to manage natural and man-made disasters at the two sites by building their capacity to properly coordinate to be better prepared to react to disasters.

APELL process conducted in Sri Lanka was based on the APELL 10 steps as outlined in the APELL handbook and the following key tasks were implemented during the project period:

1. One-day National Seminar to launch the APELL project and to raise awareness among key high-level government stakeholders,
2. One-day APELL training for the Local Coordinating Groups,
3. One-day APELL training of trainers session for the Resource Persons identified and other key experts from academia and local level government institutions,
4. Two training sessions on APELL of three days each for the local level institutions, the local emergency services, key representatives of the industry and key community representatives,
5. Two APELL site demonstrations in Ekala and Koggala,
6. Development of integrated emergency preparedness plans for two sites,
7. Translation of APELL technical materials into other national languages (Sinhala and Tamil languages).

The APELL initiative succeeded in ensuring national level government support for the APELL implementation in line with the National Disaster Management Strategy of the Disaster management Centre (DMC) because of the formation of the APELL Core Group comprising of high ranking officers of all stakeholder institutions.

The close coordination and the intimate mutual relationship maintained with these agencies throughout the project period were helpful in many ways and result in the achievement of the project objectives.

The APELL project took initiative in raising awareness and preparedness for emergencies with respect to industrial hazards. This has been emphasized in the 'Road Map for Disaster Risk Management' prepared by the DMC which is a guiding document for Disaster Management in Sri Lanka.

Residential training programs and Local Coordinating Group meetings conducted regularly at each site have established close relationship amongst the three components (local level institutions, industrial community and local communities) and also helped to develop consciousness, team spirit and to build consensus to reach a common target. The Integrated Emergency Preparedness Plans prepared for KEPZ and EIE has been very significant achievement of the APELL project.

In view of the importance of the APELL material in terms of its technical content, the Department of Engineering of the University of Moratuwa, Sri Lanka decided to include the APELL training module on 'emergency planning' in the University curriculum and this too was a great achievement of the APELL project.

P 5.3 Projects of the UNECE Convention of the Transboundary Effects of Industrial Accidents to Support Prevention, Preparedness and Response to Natechs

SP5.3 Chris DIJKENS (Chair of the Conference of the Parties to the UNECE Convention of the Transboundary Effects of Industrial Accidents)
Virginia Fuse (UN Economic Commission for Europe)

The presentation is to briefly introduce the projects under the Convention to support countries, especially those with economies in transition, in preventing, preparing and responding to industrial accidents, including the effects of such accidents caused by natural disasters.

In particular, the presentation is to mention:

- Project on evaluation of safety reports and on-site inspections during which checklist to support evaluation of safety reports and preparation for inspections was prepared and which addresses the aspects crucial in dealing with Natechs;
- Project on hazard and crisis management in the Danube Delta, which promotes further strengthening of safety at oil terminals through improved cooperation of Danube Delta countries, including taking into consideration the aspects of natural hazards: for hazard management through use of checklist for safety assessment of facilities hazardous to waters – water risk index taking into account natural hazards, for crisis management through exercises with scenarios taking into account natural hazard;
- Project on identification of hazardous activities, which promotes the approach of worst-case scenario analysis;
- Projects through which safety guidelines and good practices for pipelines and tailing management facilities were developed which address the aspects crucial to Natechs for both types of facilities.

V b Presentation V.4 – V.5: International Assistance

P5.4 International Chemical Environment

SP5.4 Jos VERLINDEN (cefic)

The chemical industry has an excellent track record in transport safety and makes every effort to transport its goods in a safe way. In case of a chemical transport accident, the industry provides information and advice, and, if possible practical assistance to emergency services to minimise adverse effects. Normally the company owning the product will provide this information and assistance but if this is not possible, the emergency services can activate the European ICE (Intervention in Chemical transport Emergencies) scheme of mutual assistance.

The ICE scheme, coordinated by Cefic, is based on a European network of national response schemes, each based upon an agreement between the national authorities and the national chemical association. Such schemes use the voluntary commitment of companies, willing to provide mutual assistance in transport accidents, upon requests from the public emergency services. The national schemes are managed by the respective national chemical associations.

Participating companies provide to the national chemical association up-to-date contact data, the list of products for which they can assist and the level of assistance offered (by phone or on site with or without equipment).

At present, national schemes have been established in 17 countries, each with a national centre, hereby involving more than 600 chemical companies, and covering all goods that are classified as dangerous for transport by ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road).

The total number of interventions provided by the 17 national schemes is approximately 2,200/year of which 50 involve assistance across national boundaries.

P5.5 The Hazard Identification Tool (HIT) – a Tool to Identify and Address Secondary Environmental Risks

SP5.5 Dennis BRUHN (OCHA Environmental emergencies section)

Natural disasters and conflicts often have secondary impacts, including damage to infrastructure and industrial installations. These so-called environmental emergencies may pose a threat to the health, security and welfare of both the affected population and the emergency responders. Too often, these risks are neglected, resulting in preventable deaths and injuries. It is, therefore, essential that relevant authorities and emergency responders have information on the location of the hazardous facilities and the potential impacts at a very early stage of the disaster response.

Countries that have developed a national disaster plan that includes a national environmental contingency plan will have this information available for relevant authorities and emergency responders prior to the onset of a disaster. These countries will respond both more quickly and more effectively to environmental emergencies within their borders. This information will then contribute to targeted mitigation measures and requests for further specialized assistance if needed.

The Hazard Identification Tool (HIT) was developed by the Joint UNEP/OCHA Environment Unit (Joint Environment Unit/JEU) as a support tool for the United Nations Disaster Assessment and Coordination (UNDAC) Team and other emergency first responders, including environmental experts, to raise awareness of the need to identify and address secondary environmental risks as early as possible in the event of a natural disaster or a conflict and as a basis for on-site investigations and field assessments. The HIT is based on the methodology of the Flash Environmental Assessment Tool (FEAT), a scientific assessment methodology to detect the most acute hazards to human health and the environment after natural disasters. The FEAT and the HIT both use the same framework for estimating the type of impact of each identified risk. (Impact type is recorded in the fifth column of the HIT form – see below.) Both the FEAT and the HIT are typically used together in the international response to environmental emergencies. The HIT provides a list of big and obvious potential secondary risks in any area that might experience natural disasters or conflicts. This includes large infrastructure installations like dams, nuclear facilities, hazardous waste storage sites and industrial facilities.

Contributions not Presented

Session I c Warning Systems

SAFE An Example of an Extreme Weather Hazard Warning System for Communities and Industries

Ulrich MEISSEN (Fraunhofer Institute for Open Communication Systems, Germany)

In the past decade, we witnessed strong efforts in establishing effective Early Warning Systems (EWS) not only for natural hazards but also increasingly for anthropogenic, technical, or biological risks. Experiences from early warning projects indicate the importance of integrating private stakeholders, especially when it comes to cost-effective and sustainable long-term operation of such systems. Moreover, given the investment requirements in this area, such as for effective alerting technologies for the public, the integration of private resources becomes inevitable.

One important challenge in the successful implementation or improvement of an early warning system is evaluating and monitoring its efficiency. Yet there is no common proven evaluation approach and one of the major open research issues is the elaboration of cost-benefit models in this area. With the integration of private stakeholders, a quantitative model is becoming of major importance. In addition, the involved authorities need to have decision support tools to effectively invest into better disaster prevention and mitigation.

In this context we present SAFE, an a applied research pilot system aiming at local early warning systems of high quality, supported by technological disaster prevention measures that can make a significant contribution to protection from extreme weather hazards effects. The approach of SAFE is to use new sensor, system, and telemetric technologies in order to enhance the local quality of weather hazard prognoses and to perform targeted information dissemination for affected persons and systems. The central approach for enabling these new technologies and ensuring sustainability is the strong integration of private stakeholders in the project and in the long-term operation model of the system. The project successfully unites the interests of local authorities, insurances and larger industries, in particular the chemical industry.

The presentation includes a description of the development steps, field tests and the findings of the SAFE project. Based on user surveys, the interests and possible response activities of the different stakeholders have been investigated and transferred to the technological and operational requirements of a new generation EWS that sets high standards in terms of information quality, dissemination effectiveness for industry standards. This technological basis enables the realization of a variety of operational models for different stakeholders sharing the same infrastructure and thus being highly cost-effective. We consider SAFE as a blueprint for the successful technological cooperation of public and private stakeholders for better disaster prevention in the context of natural and industrial risks.

Istanbul Earthquake Rapid Response and Early Warning System

Mustafa ERDIK (Bogazici University, Turkey)

Potential impact of large earthquakes on urban societies can be reduced by timely and correct action after a disastrous earthquake. Modern technology permits measurements of strong ground shaking in near real-time for urban areas exposed to earthquake risk. As part of the preparations for the future earthquake in Istanbul a Rapid Response and Early Warning system in the metropolitan area is in operation.

The Istanbul Earthquake Rapid Response System equipped with 100 instruments and two data processing centres aims at the near real time estimation of earthquake damages using most recently developed methodologies and up-to-date structural and demographic inventories of Istanbul city. After the transmission of ground motion parameters by the field stations, shake and building damage distribution maps, using spectral displacement based fragility relationships, are automatically generated and transmitted to emergency operation centres within 3 minutes using radio modem and GSM communication. The system has so far exposed to several small magnitude (ML=3-4) earthquakes and performed satisfactorily. The methodology developed for near real time estimation of losses after a major earthquake consists of the following general steps:

1. rapid estimation of the ground motion distribution using the strong ground motion data gathered from the instruments;
2. improvement of the ground motion estimations as earthquake parameters become available and
3. estimation of building damage and casualties based on estimated ground motions and intensities.

For the Early Warning system ten strong motion stations were installed as close as possible to the fault zone to transmit on-line data via digital radio modem and satellite telemetry. A simple and robust Early Warning algorithm, based on the votes of exceedance of specific filtered acceleration and cumulative absolute velocity (CAV) levels are implemented. The users of the early warning signal are power and gas companies, nuclear research facilities, critical chemical factories, subway system and several high-rise buildings.

Session II

Natech accidents happened during 12 May 1998 Wenchuan earthquake and risk prevention measures in China

QI Yanhong (Environmental Emergency & Accident Investigation Center (EEAIC), Peoples Republic of China)

The Environmental Emergency & Accident Investigation Center (EEAIC) is in charge of emergency response to major environmental pollution accidents and ecological damages as well as investigation of major and key environmental pollution accidents. The EEAIC guides and coordinates local governments to properly handle any major environmental pollution accidents. THE EEAIC is strengthening the management of emergency planning, preparedness, response and risk assessment.

The EEAIC has been developing cooperation with Canada Ministry of Environment on environmental emergencies from 2010.

Abstract of presentation:

1. Introduce the accidents happened during 12 May 1998 Wenchuan earthquake and activities in emergency responding.
2. Introduce current activities on Natech risk prevention, which include chemical risks investigation, hazard identification, risk assessments, risk prevention plans, and the risk management policies for operators and authorities.
3. Introduce existing problems in prevention Natech accidents
4. Recommendation and conclusion

List of Participants

Participants list for OECD Workshop on Natech Risk Management

Liste des participants à l'Atelier OCDE sur la gestion des risques des accidents "Natech"

Dresden, Germany

23/5/2012 - 25/5/2012

Austria/Autriche

Mr. Armin HEIDLER
V/1 - Plant-related environmental Protection
Federal Ministry for Agriculture, Forestry, Environnment and Water Management
V/1 - Plant-related environmental Protection
Stubenbastei 5
1010 Vienna
Austria

Tel: +43 1 51522-2109
Fax: +43 1 51522-7122
Email: armin.heidler(at)lebensministerium.at

Belgium/Belgique

Dr. Philippe RAUCQ
Attaché
Direction des Risques Industriels Géologiques et Miniers
Public Service of Wallonia (SPW)
Cellule Risque d'Accidents Majeurs
AVENUE PRINCE DE LIEGE 15
5100 Jambes
Belgium

Tel: +32 81 33 64 24
Fax: +32 81 33 65 44
Email: philippe.raucq(at)spw.wallonie.be

Canada

M. Jean-Paul LACOURSIÈRE
Professeur associé
Ingéniérie chimique
Université de Sherbrooke
35, rue Lemoyne
J6A 3L4 Repentigny
Canada

Tel: +1 (450) 581-2315
Fax: +1 (450) 581-4539
Email: jpla(at)sympatico.ca

Czech Republic/République tchèque

Mr. Pavel DANIHELKA
Head of the Lab on Research and Risk MGT
Faculty of Risk Enggineering
Technical University of Ostrava
Ostrava
Lumírova 13
Ostrava-Výškovice
Czech Republic

Tel: +420 597 322 822
Fax: +420 597 322 983
Email: pavel.danihelka(at)vsb.cz

Mr. Pavel DOBES
Researcher
Faculty of Safety Engineering
Technical University of Ostrava
Lumírova 13
700 30 Ostrava
Czech Republic

Tel: + 420 597 322 883
Fax: + 420 597 322 983
Email: p.dobes(at)centrum.cz

Finland/Finlande

Mrs. Leena AHONEN
Senior Safety Engineer
Safety Technology Authority
Lönnrotinkatu 37
00180 Helsinki
Finland

Tel: +358 405 788 249
Fax: +358 759 1596
Email: leena.ahonen(at)tukes.fi

France

M. Cédric BOURILLET
Head
Accidental Risk Division
Ministry of Ecology, Sustainable Development, Transport and Housing/Ministère de l'Ecologie (MEDDTL) - DGPR/SRT/SDRA
Grande Arche de la Défense
92055 La Défense Cedex
France

Tel: +33 1 40 81 89 79
Fax: +33 1 42 19 13 93
Email: cedric.bourillet(at)developpement-durable.gouv.fr

Mrs. Maud CASIER
Chargée de mission
Direction Générale de la Prévention des risques
Ministry of Ecology, Sustainable Development, Transport and Housing (MEDDTL)
Bureau des risques technologiques et des industrie
Grande Arche Paroi Nord 92055 La Défense Cedex
France

Tel: +33 1 40 81 90 21
Email: maud.casier(at)developpement-durable.gouv.fr

Ms. Ana Maria CRUZ NARANJO
Consultant
HSE, IUT
Université de Bordeaux I
11, rue Jean Mermoz
33800 Bordeaux
France

Tel: +33 556 743596
Email: ana-maria.cruz(at)u-bordeaux1.fr

Ms. Carine EL HAJJ
PhD Student in Risk Management
Institut Fayol
Ecole Nationale Supérieure des Mines de Saint Etienne (ENSME)
158, cours fauriel
42023 Saint etienne
France

Tel: +33 477499758
Email: elhajj(at)emse.fr

M. Jean-Paul MONET
Lieutenant-colonel / Conseiller technique Nrbc zonal
French Fire and EM Services
Service départemental d'incendie et de secours des Bouches du Rhône - SDIS 13
Place Jean Jaurès
Immeuble Lou Gabian, Bât E
13130 Berre
France

Tel: + 33 4 42 34 00 12
Email: JPMONET(at)sdis13.fr

Mr. Xavier STREBELLE
Adjoint au chef du bureau des risques technologiques des industries chimiques et pétrolières
Direction générale de la prévention des risques
Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer
Grande Arche de la Défense
92055 La Défense Cedex
France

Tel: +33 1 40 81 89 78
Email: xavier.strebelle(at)developpement-durable.gouv.fr

Ms. Agnès VALLEE
Direction des Risques Accidentels
INERIS
Parc Technologique ALATA - BP2
60550 Verneuil-en-Halatte
France

Tel: +(33)3 44 55 62 44
Fax: +(33) 3 44 55 62 95
Email: agnes.vallee(at)ineris.fr

M. Adrien WILLOT
Ingénieur
Unité Résistance des structures Direction des Risques Accidentels
INERIS
88 boulevard Lahitolle
18020 Bourges

Tel: + 33 2 48 48 40 43
Fax: + 33 2 48 48 40 34
Email: adrien.willot(at)ineris.fr

Germany/Allemagne

Dr. Matthias ANDRES
CEO
Ingenieurgesellschaft
Krätzig & Partner
Buscheyplatz 9-13
44801 Bochum
Germany

Tel: +49 234 709940
Email: andres(at)kraetzigundpartner.de

Mr. Roland FENDLER
Industrial Installation Safety
Federal Environmental Agency
Woerlitzer Platz 1
06844 Dessau
Germany

Tel: +49-340-2103-3679
Fax: +49-340-2104-3679
Email: roland.fendler(at)uba.de

Mr. Mark HAILWOOD
Scientific Employee, Chair of the OECD Working Group on Chemical Accidents
Technical Environmental Protection
LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg
Griesbachstr. 1
76185 Karlsruhe
Germany

Tel: +49-721-5600-3181
Fax: +49-721-5600-3200
Email: mark.hailwood(at)lubw.bwl.de

Mr. Georg BÖHME-KORN
Saxon State Ministry of the Environment and Agriculture
Wilhelm-Buck-Str. 2
01097 Dresden
Germany

Dr. Dieter COHORS-FRESENBORG
Federal Environmental Agency (Umweltbundesamt)
Wörlitzerplatz 1
06844 Dessau-Rosslau
Germany

Tel: +49 340 2103 3233
Fax: +49 340 2104 3233
Email: dieter.cohors-fresenborg(at)uba.de

Dr. Ursula FISCHBACH
Commission on Process Safety (KAS)
Merowingerstr. 88
40225 Dusseldorf
Germany

Tel: +49 6151 629 3617
Fax: +49 61 403 0105
Email: u.fischbach(at)gmx.de

Mr. Peter GAMER
Head of Division
Plant-Related Emissions and Noise
Saxon State Agency for the Environment, Agriculture and Geology
Pillnitzer Platz 3
01326 Dresden-Pillnitz

Tel: +49 351 2612 5200
Email: peter.gamer(at)smul.sachsen.de

Dr. Wolfgang GIERKE
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Robert-Schuman-Platz 3
D-53175 Bonn
Germany

Tel: 49 228 305 2460
Fax: 49 228 305 3225
Email: wolfgang.gierke(at)bmu.bund.de

Ms. Luise HUTKA
Research Associate
Professorship of Geoinformation Systems
Technische Universität Dresden
Helmholtzstr. 10
01062 Dresden
Germany

Tel: +49 351 463 33576
Email: luise.hutka(at)tu-dresden.de

Mr. Leo IBERL
Air Quality Management and Industrial Plant Safety
Bavarian State Ministry of the Environment and Public Health
Rosenkavalierplatz 2
81925 Munich
Germany

Tel: +49 89 9214 2124
Fax: +49 89 9214 2451
Email: leo.iberl(at)stmug.bayern.de

Mr. Fritz Jaeckel
Secretary of Staate
Saxon State Ministry of the Environment and Agriculture
Wilhelm-Buck-Str. 2
01097 Dresden
Germany

Professor Christian JOCHUM
European Process Safety Centre (EPSC)
Robert-Stolz-Str. 54
D-65812 BAD SODEN
Germany

Tel: 0049-6196-61656
Fax: 0049-6196-61657
Email: chr.jochum(at)t-online.de

Mr. Oliver KALUSCH
Federal Association of Environmental Action Groups (BBU)

Tel: +49 2302 95 640 95
Email: ursula.weiss(at)rub.de

Mr. Michael KLEIBER
TA
Safety of Installations
Federal Environmental Agency
Woerlitzer Platz 1
06844 Dessau
Germany

Tel: +49 340 2103 3019
Email: michael.kleiber(at)uba.de

Mr. Matthias KNÜPFER
Anlagenbezogener Immissionsschutz, Lärm
Saxon State Agency for the Environment, Agriculture and Geology
Söbrigener Str. 3a
01326 Dresden
Germany

Tel: +49 351 2612 5205
Email: Matthias.Knuepfer(at)smul.sachsen.de

Dr. Karl-Erich KOEPPKE
Consultant
Ing. Bureau Dr. Koeppke
Elisabethstraβe 31
D-32545 Bad Oeynhausen
Germany

Tel: +49 5731 26111
Email: dr.Koeppke(at)t-online.de

Mr. Wilfried KÜCHLER
Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie
Pillnitzer Platz 3
01326 Dresden
Germany

Tel: +49 351 2612 5502
Email: Wilfried.Kuechler(at)smul.sachsen.de

Mr. Stephan KURTH
Nuclear Technology and Facility Safety Division
OEko-Institut e.V.
Rheinstr. 95
64295 Darmstadt
Germany

Tel: +49 160 533 3354
Email: s.kurth(at)oeko.de

Mr. Christian LAHNSTEIN
Legal Counsel
Claims Management and Consulting
Munich Re
80791 Munich
Germany

Tel: +49 89 3891 9611
Fax: +49 89 3891 79611
Email: clahnstein(at)munichre.com

Mr. Ulrich MANN
Student
Cartography/GIS
TU Dresden

Tel: +49 1627690661
Email: ulrich.mann(at)mailbox.tu-dresden.de

Mr. Ulrich MEISSEN
Head of Competence Center ESPRI
Electronic Safety and Security Systems for the Public and Industries
Fraunhofer Institute for Open Communication Systems FOKUS
Steinplatz 2
10623 Berlin
Germany

Tel: +49 30 24 306 450
Email: ulrich.meissen(at)fokus.fraunhofer.de

Mr. Rainer MÜTTERLEIN
Saxon State Ministry of the Environment and Agriculture
Pillnitzer Platz 3
01326 Dresden
Germany

Tel: +49 351 2612 5206
Email: Rainer.Muetterlein(at)smul.sachsen.de

Ms. Ruth OLDENBRUCH
Division IG 1 4, Federal Ministry for the Environment
Federal Ministry for Environment, Nature Conservation and Nuclear Safety
Robert-Schuman-Platz 3
53175 Bonn
Germany

Tel: + 49 - 228 - 99305 2461
Fax: + 49 - 228 - 99305 2402
Email: ruth.oldenbruch(at)bmu.bund.de

Dr. Norbert SCHIESS
Head of Division
Installation-related Pollution Control, Accident Prevention
Saxon State Ministry of the Environment and Agriculture
Wilhelm-Buck-Str. 2
01097 Dresden
Germany

Tel: +49 351 564 6530
Fax: +49 351 564 6529
Email: Norbert.Schiess(at)smul.sachsen.de

Mr. Samuel SCHIESS
Student
University of Dresden

Tel: +49 162 7869693
Email: samuelschiess(at)gmx.de

Mr. Wolfgang SCHLÖSINGER
Control of Major Accident Hazards Involving Dangerous Substances
State Agency for Nature, Environment and Consumer Protection, North Rhine-Westphalia
Leibnizstr. 10
45659 Recklinghausen
Germany

Tel: +49 201 7995 1937
Fax: +49 201 7995 1910
Email: wolfgang.schloesinger(at)lanuv.nrw.de

Ms. Simone SCHMIDT
Desk Officer
Saxon State Ministry of the Environment and Agriculture
Archivstr. 1
01076 Dresden
Germany

Tel: +49 351 564 6532
Fax: +49 351 564 6529
Email: Simone.Schmidt(at)smul.sachsen.de

Professor Martin SOCHER
Professor
Sächsisches Staatsministerium für Umwelt und Landwirtschaft
Archivstr. 1
01097 Dresden
Germany

Tel: +49 351 564 2440
Email: martin.socher(at)smul.sachsen.de

Mr. Manfred STOCK
Potsdam Institute for Climate Impact Research (PIK)
Telegraphenberg A 31
14473 Potsdam
Germany

Tel: +49 331 288 2500

Dr. Gernot THUMA
Reactor Safety Analyses
GRS
Schwertnergasse 1
50667 Köln
Germany

Tel: +49 (0)221 2068 607
Fax: +49 (0)221 2068 10607
Email: Gernot.Thuma(at)grs.de

Ms. Johanna WATOROWSKI
Process Safety
Federal Environment Agency

Tel: +49 157 8678 1996
Email: johanna.watorowski(at)uba.de

Mr. Gerhard WINKELMANN-OEI
Safety of Installations
Federal Environmental Agency
Woerlitzer Platz 1
06844 Dessau
Germany

Tel: +49 340 2103 3289
Email: gerhard.winkelmann-oei(at)uba.de

Israel/Israël

Dr. Efraim LAOR
Lecturer
Homeland Security Academy
Zinman College at the Wingate Institute

Tel: +972 50 6370579
Email: laor10(at)zahav.net.il

Italy/Italie

Dr. Francesco ASTORRI
SMS Inspector, GIS Analyst
Industrial Risk Service
Institute for Environmental Protection and Research(ISPRA)
Industrial Risk Office
Via Cesare Pavese, 305
00144 Rome
Italy

Tel: +39 06 50072524
Fax: +39 06 50072531
Email: francesco.astorri(at)isprambiente.it

Dr. Valerio COZZANI
Department of Chemical Engineering
Alma Mater Studiorum - Università di Bologna
DICMA - via Terracini 28
40131 Bologna
Italy

Tel: +390512090240
Fax: +390512090247
Email: valerio.cozzani(at)unibo.it

Mr. Andrea SANTUCCI
Directorate for the Environmental Protection
Ministry of Environment and Land Protection
Rome
Via Cristoforo Colombo, 44
Rome
Italy

Tel: 0039 06 5722 5045
Email: santucci.andrea(at)minambiente.it

Japan/Japon

Dr. Yuji WADA
Group Leader
Research Institute of Science for Safety and Sustainability (RISS)
National Institute of Advanced Industrial Science and Technology (AIST)
AIST West Site,
16-1 Onogawa
305-8569 Tsukuba
Japan

Tel: +81 29 861 8837
Fax: +81 29 861 8763
Email: yuji.wada(at)aist.go.jp

Netherlands/Pays-Bas

Mr. Chris DIJKENS
Director, International Enforcement Cooperation
ILT/Hazardous Substances and Products
Ministry of Infrastructure and the Environment
Graadt van Roggenweg 500
3531 AH Utrecht
Netherlands

Tel: +31 70 339 1421
Email: chris.dijkens(at)ILenT.nl

Mr. Peter J.M.G. FRIJNS
Safety and Risks Department
Ministry of Infrastructure and the Environment
Rijnstraat 8
P.O Box 20901
2500 EX The Hague
Netherlands

Tel: +31 (70) 339 4429
Fax: +31 (70) 339 1286
Email: Peter.Frijns(at)minIenM.nl

Ms. Anneke RAAP
Senior Policy Maker
Safety and Risks
Ministry of Infrastructure and Environment

Tel: +31 70 456 6302
Email: anneke.raap(at)minienm.nl

Mr. William F.J. VAN BERKEL
General Water Policy and Safety Department
Ministry of Infrastructure and the Environment
P.O. Box 20904
2500 EX The Hague
Netherlands

Tel: +31 615 359 589
Email: william.van.berkel(at)minIenM.nl

Norway/Norvège

Ms. TORILL F. TANDBERG
Director of Department
Industry, Products and Hazardous Substances
Directorate for Civil Protection and Emergency Planning
Ramberg veien 9
P.O.Box 2014
N-3103 Tønsberg
Norway

Tel: +47 33412750
Email: torill.tandberg(at)dsb.no

Ms. Vibeke HENDEN NILSSEN
Senior Engineer
Directorate for Civil Protection and Emergency Planning
PO Box 2014
NO-3103 Tønsberg
Norway

Email: vibeke.henden.nilssen(at)dsb.no

Switzerland/Suisse

Mr. Daniel BONOMI
Deputy Head of Section
Section Safety of Installations and Earthquake Mitigation
3003 Berne
Switzerland

Tel: +41 31 322 93 98
Fax: +41 31 324 78 66
Email: daniel.bonomi(at)bafu.admin.ch

Mr. Hans KIENHOLZ
KiNaRis
Caecilienstrasse 31
3007 Berne
Switzerland

Tel: +41 31 371 04 31
Email: kienholz(at)kinaris.ch

Turkey/Turquie

Professor Mustafa ERDIK
Chairman
Dept. of Eq. Eng. Bogazici University, Istanbul
Kandilli Observatory and Earthquake Research Institute
81220 Cengelkoy
Turkey

Tel: 00 90 216 332 6560
Fax: 00 90 216 308 0163
Email: erdik(at)boun.edu.tr

Dr. Serkan GIRGIN
Biskek Cad. 83. Sok. No:7/4 Emek
06510 Ankara
Turkey

Tel: +90 312 2220196
Email: girgink(at)gmail.com

Mr. Ahmet GOKTAS
Expert
Chemicals Management Department
Ministry of Environment & Urbanization
06000 Ankara
Turkey

Tel: +90 (312) 586 32 55
Fax: +90 (312) 474 03 18
Email: ahmet.goktas(at)csb.gov.tr

Ms. Betül KURADA
AFAD Assistant Specialist, Environmental Engineer
Department of Planning & Mitigation
Prime Ministry Disaster and Emergency Management Presidency
Basbakanlik Afet ve Acil durum Yönetimi Baskanligi
mustafa kemal mahallesi dumlupinar bulvari no:274
06800 Ankara
Turkey

Email: betul.kurada(at)afad.gov.tr

Mr. Mehmet Fatih SEN
AFAD Assistant Specialist & Environmental Engineer
Department of Planning & Mitigation
Turkish Prime Ministry Disaster & Emergency Management Presidency
Mustafa Kemal Mah. Dumlupinar Bulvari No:274
Ankara
Turkey

Tel: +90 (312) 287 26 80
Fax: +90-312-2873851
Email: fatih.sen(at)afad.gov.tr

United Kingdom/Royaume-Uni

Mr. John BREWINGTON
Environment Agency
Trentside Offices
Scarrington Road, West Bridgford, Nottingham
NG2 5FA
United Kingdom

Tel: + 44 (0) 115 8463627
Email: john.brewington(at)environment-agency.gov.uk

Ms. Judith GOLOVA
Broker, Environmental Insurance
Environmental Practice
Marsh Ltd
Tower Place
EC3R 5 BU London
United Kingdom

Tel: +44 20 7357 3675
Email: judith.golova(at)marsh.com

Mr. Gary THORNTON
Asset Strategy & Engineering Manager
Electricity Network Investment
National Grid
2 Herring Road
CV9 2NZ Atherstone
United Kingdom

Tel: +44 7785 527 154
Email: gary.thornton(at)nationalgrid.com

EU/UE

Professor Aleksandar JOVANOVIC
CEO
European Virtual Institute for Integrated Risk Management
Haus der Wirtschaft, Willi-Bleicher-Straße 19
D- 70174 Stuttgart
Germany

Tel: +49 711 1839 781
Fax: +49 711 1839 685
Email: jovanovic(at)eu-vri.eu

Dr. Elisabeth KRAUSMANN
Joint Research Centre
European Commission
Via E. Fermi 2749
21027 Ispra (VA)
Italy

Email: elisabeth.krausmann(at)jrc.ec.europa.eu

People's Republic of China/République populaire de Chine

Ms. Qi YANHONG
Division Director, Division of General Affairs
Center of Environmental Emergency & Accident Investigation
Ministry of Environment Protection
115 Xizhimennei Nanxiaojie
100035 Beijing
People's Republic of China

Tel: +86 10 6655 6462
Fax: +86 10 6655 6983
Email: qiyanhong(at)sohu.com

Philippines

Ms. Jean BORROMEO
Supervising Environmental Management Specialist
Manila Bay Coordinating Office/Office of the Undersecretary for Field Operations
Department of Enviroment and Natural Resources

Tel: +63 292 81225
Email: guinivere_ph(at)yahoo.com

Romania/Roumanie

Ms. Maria Magdalena DUTA-GHERGUT
Senior Adviser
Risk Management (Seveso)
National Environmental Protection Agency

Tel: + 40 722 68 76 47
Email: magda.duta(at)anpm.ro

Ms. Marilena GHIU
Senior Advisor
Directorate for Pollution Control and Impact Assessment
Ministry of Environment and Forests
12 Libertatii Blvd. Sector 5
RO-040129 Bucharest
Romania

Tel: +40 740 52 86 41
Email: marilena.ghiu(at)mmediu.ro

Mr. Francisc SENZACONI
Head of Major Accidents Risk Activities Control Bureau (Seveso)
Disaster Prevention
General Inspectorate for Emergency Situations
Disaster Prevention Office
Bucharest
Romania

Tel: +40 744 33 57 75
Email: senzacof(at)mai.gov.ro

Sri Lanka

Mr. Jayavilal FERNANDO
Deputy Director General & Project Director
Environmental Education & Awareness/National Solid Waste Disposal Facility Project
Central Environmental Authority
No. 104. Denzil Kobbekaduwa Mawatha
Battaramulla
Sri Lanka

Tel: +94 0094-11-2872297
Fax: +94-11-2872609
Email: jayavi(at)cea.lk

Business and Industry Advisory Committee (BIAC)/Comité consultatif économique et industriel (BIAC)

Ms. Monika BAER
BASF SE
Ludwigshafen
67056
Germany

Tel: +49621 6049296
Email: monika.baer(at)basf.com

Mr. Charles COWLEY
Staff Consultant
Center for Chemical Process Safety
American Institute of Chemical Engineers
3 Park Avenue
10016-5991 New York
United States

Tel: +44 7771 650308
Email: charlescowley(at)btinternet.com

Dr. Helge-Juergen DARGEL
BTS-PME-CSA
Bayer Technology Services
B610
51368 Leverkusen
Germany

Tel: +49 214 305 0619
Email: helge-juergen.dargel(at)bayer.com

Dr. Caspar-Heinrich FINKELDEI
Evonik Industries AG
Rodenbacher Chaussee 4
63457 Hanau
Germany

Tel: +49 6181 59 6199
Fax: +49 6181 59 76199
Email: caspar-heinrich.finkeldei(at)evonik.com

Mr. Richard GOWLAND
Technical Director
European Process Safety Centre
165-189 Railway Terrace
CV21 3HQ Rugby
United Kingdom

Tel: +44 1485 572 384
Fax: +44 1485 572 384
Email: rgowland-epsc(at)icheme.org

Mr. Thilo HÖCHST
Verband der Chemischen Industrie e. V.
Chemical Industry Association
Mainzer Landstrasse 55
60329 Frankfurt am Main
Germany

Tel: +49 69 2556 1507
Fax: +49 69 2556 2507
Email: hoechst(at)vci.de

Mr. Josef SCHORR
GUU/LZ - Umweltzentrale
BASF SE

Tel: +49 621 60 49080
Fax: +49 173 347 86 13
Email: josef.schorr(at)basf.com

Mr. Björn THRUN
TÜV Rheinland Industrie Service GmbH (TÜV Rhineland Industry Service)
Alboinstr. 56
12103 Berlin
Germany

Tel: +49 30 7562 1682
Fax: +49 30 7562 1724
Email: Bjoern.Thrun(at)de.tuv.com

Mr. Jos VERLINDEN
Director, Transport and Logistics
CEFIC
Av. E. van Nieuwenhuyse 4
1160 Brussels
Belgium

Tel: +32 2 676 73 95
Fax: +32 2 676 74 32
Email: jve(at)cefic.be

Mr. Christian WEISS
Industrial Advisory Service Peguera S.L.
Betriebsstätte Deutschland
Robert Koch Str. 8
50181 Bedburg
Germany

Tel: +49 2272 97 89 180
Fax: +49 22729789181
Email: Christian.Weiss(at)IASP.biz

UN Economic Commission for Europe (UNECE)/Commission économique pour l'Europe des Nations Unies (CEE-ONU)

Ms. Virginia FUSÉ
Programme Officer
Environment Division
United Nations Economic Commission for Europe
Palais des Nations
8-14 avenue de la Paix
1211 Geneva
Switzerland

Tel: +(00)41 22 917 4149
Fax: +(00)41 22 907 01 07
Email: virginia.fuse(at)unece.org

UN Environment Programme (UNEP)/Programme des Nations Unies pour l'environnement (PNUE)

Mr. Dennis BRUHN
UN Environment Programme (UNEP)
Kloverprisvej 89
2650 Hvidovre
Denmark

Tel: +45 2723 6478
Email: dennisbruhn(at)email.dk

Rene NIJENHUIS
Humanitarian Affairs Officer - Environmental Emergencies Section
Emergency Services Branch
UNEP/OCHA
Office for the Coordination of Humanitarian Affair
Palais de Nations - bureau D-119
CH 1211 Geneva
Switzerland

Tel: +41 22 917 1815
Fax: +41 22 917 0257
Email: nijenhuis(at)un.org

Ms. Katsiaryna PAULEVETS
Business & Industry Unit - Sustainable Consumption and Production Branch
United Nations - Environment Programme (UNEP)
Division of Technology, Industry and Economics
15 rue de Milan
75009 Paris
France

Tel: +33 1 44 37 42 91
Email: katsiaryna.paulavets(at)unep.org

OECD/OCDE

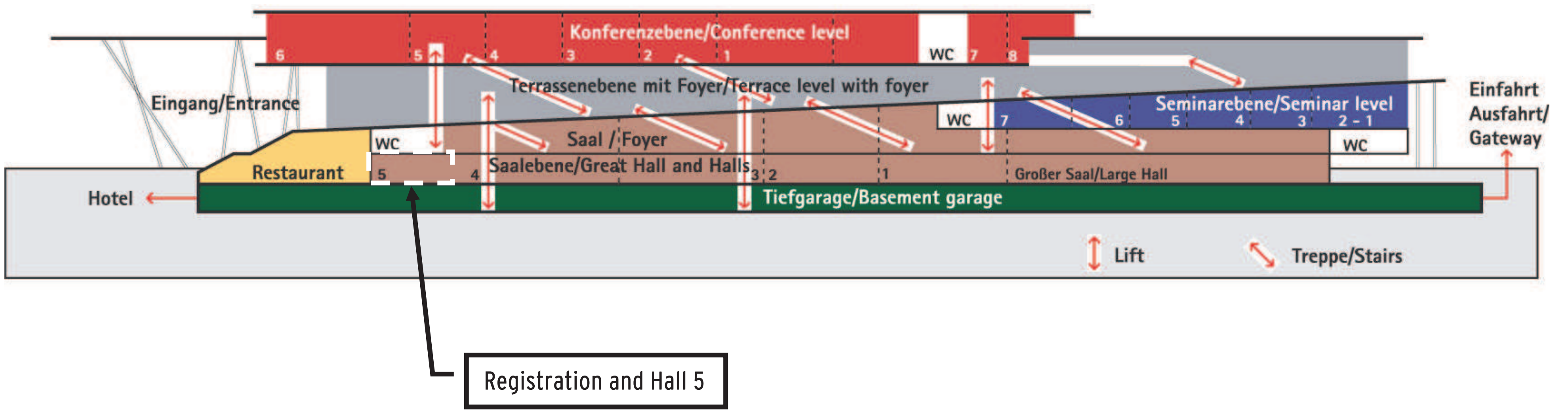
Mme Marie-Chantal HUET
Administrator, Chemical Accidents
ENV/EHS
OECD
Marshall Building 0283
2 rue André-Pascal
75016 Paris
France

Tel: +(33-1) 45 24 79 03
Fax: +33 1 44 30 61 80
Email: Marie-Chantal.HUET(at)oecd.org

Mr. Peter KEARNS
Principal Administrator
ENV/EHS
OECD
Marshall Building 0285
2 rue André-Pascal
75016 Paris
France

Tel: +(33-1) 45 24 16 77
Fax: +33 1 44 30 61 80
Email: Peter.KEARNS(at)oecd.org

International Congress Center Dresden



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