FINNISH PROJECT ON ENVIRONMENTAL RISK ANALYSIS OF INCIDENTAL EMISSIONS

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FOREWORD

The final report of the Finnish project on environmental risk analysis of incidental emissions have been published in the series of the Finnish Environment Institute only in Finnish (reference 1) that is titled "Häiriöpäästöjen ympäristöriskianalyysi. YMPÄRI-hankkeen suositukset" (Environmental risk analysis for accidental[1] emissions - Recommendations of the ENVIRI project). In May, 2007 the results were presented in the "Loss Prevention 2007 12th International Symposium" in Edinburgh (reference 2). The summary of the project has also been published in the Journal of Chemical Health and Safety in 2007 (reference 3). The text, tables and figures of this Annex II has been compiled from the three above mentioned publications.

1 INTRODUCTION

Environmental legislation and voluntary improvement activities have led to a situation where normal, continuous, process emissions are nowadays well controlled in industrial operations. More of a challenge today, however, concerns the management of incidental emissions, which may occur in abnormal or unexpected situations. These undesired events can ruin the achievements of positive development of environmental protection. Incidental emissions may have ecological and societal effects, effects to health, and influence the corporate management and impact industrial production. For these reasons, it is desirable for companies to prevent incidental emissions beforehand. One approach for improving the prevention would be to carry out an environmental risk analysis in which the possibilities of incidental emission events are identified and analysed from the point of view of different consequences.

Against this background, the Technical Research Centre of Finland (VTT), the Finnish Environment Institute (SYKE), the Finnish Ministry of the Environment (YM) and the Safety Technology Authority (TUKES) initiated a development process for the ENVIronmental RIsk analysis (ENVIRI, in Finnish the project is called YMPÄRI[2]). The aim of the process was to create a guideline for conducting an environmental risk analysis, and also to clarify risk terminology and risk acceptability in terms of the management of incidental emissions. A special focus was also put on the usability of ecological risk assessment methods in the light of environmental risk analysis. In the beginning of 2006, a further development process of

[1] In the ENVIRI project the term "accidental" was used in the same meaning as "incidental" in the IMPEL project.

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ENVIRI guidelines was also started. The aim of this project was to apply the guidelines at industrial sites, and especially to develop computer software to help document the risk analysis process. So far, a site-specific environmental risk analysis based on the ENVIRI guidelines has been performed at three Finnish industrial sites: a paper mill, a nailery, and a steelworks.

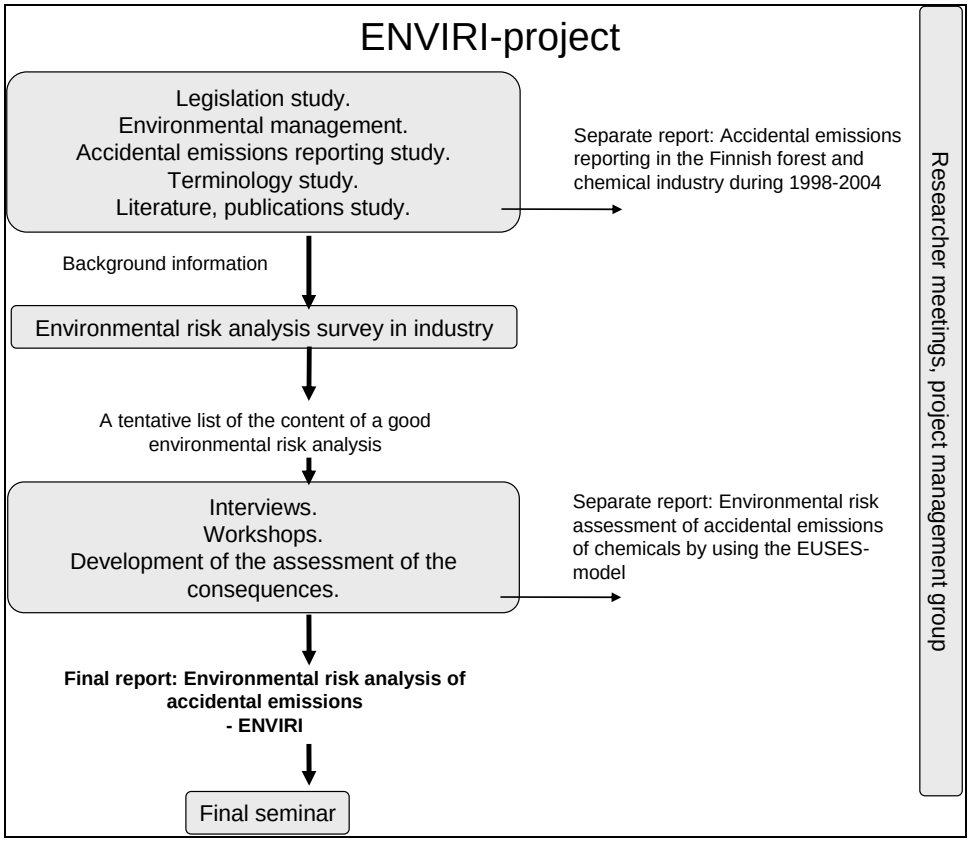

Figure 1. The development of the ENVIRI process.

2 DEVELOPMENT PROCESS

The ENVIRI process consisted of several parts (Figure 1). Firstly, the demands of legislation and voluntary environmental management system standards, as well as literature and publications, were studied. In addition, an incidental emissions reporting study was made among the Finnish forest and chemical industries.

The second part of the ENVIRI process involved making a phone survey in which 53 Finnish companies were asked about whether they performed an environmental risk analysis, and how they conducted it. Based on this survey a tentative list of the content of environmental risk analysis was created. With this list as a basis, we further interviewed companies, and consultants and certification bodies, and developed the tentative content of the environmental risk analysis.

An essential part of the project was to arrange three workshops. The results obtained from the workshops had the big influence on the content of final environmental risk analysis guideline.

Each workshop consisted of about 30 participants. Only authorities were invited to the first workshop. In the second workshop also consultants, certification bodies and companies participated in the discussions. The final workshop was open to all interested parties.

The final results were reported in a report called "Environmental risk analysis – The recommendations of the ENVIRI process". In addition, a separate report was published about incidental emission reporting and about the usage of the European Union's EUSES model in modelling the environmental risk of incidental chemical emission.

3 TERMINOLOGY AND THE CONTENT OF ENVIRONMENTAL RISK ANALYSIS

In the study, the risk terminologies used in different working/science cultures were combined in an effort to improve the communication associated with risk issues between different stakeholders. The definitions shown in Table 1 were adopted.

Table 1. ENVIRI terminology

Incidental emission	An emission, that shall mean the direct or indirect release of substances, vibrations, heat or noise, which is quantitatively or qualitatively exceptional, caused by an exceptional situation and there is a potential of environmental harm. The emission shall be released from individual or diffuse sources in the installation into the air, water or land. (modified from the IPPC Directive)
Risk	Combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event.
Environmental risk	A risk, whose consequences have effects to human health, living conditions and living environment, soil, surface waters and groundwater, air, climate, flora and fauna as well as biodiversity, community structure, buildings, scenery, cityscape and cultural heritage and all the interaction between these elements[15]. The probability of environmental risk is the frequency of an incidental emission that is released uncontrolled to the environment.
Source of danger	Potential source of danger: chemical, substance or energy.
Incidental emission situation/hazardous event/risk	An abnormal situation where an emission is released uncontrolled to the environment. Incidental emissions are emissions that pass through the protection equipment or risk management actions in the process. Near miss situations are emissions that are captured inside the process by the risk management actions.
Risk identification	Process of recognising that a source of danger and a potential for incidental emission situation exist, and this situation may cause harm to the environment.
Risk estimation	Process used to produce a measure of the level of risks being analysed. Risk estimation consists of the following steps: frequency analysis, consequence analysis and their integration.
Risk evaluation	Process in which judgements are made on the tolerability of the risk on the basis of risk analysis, and taking into account factors such as socio-economic and environmental aspects.

Environmental risk analysis	Process in which incidental emission situations/hazardous events/risks are identified and assessed systematically, and proposals for actions to diminish the environmental risk are made.
Risk assessment	Overall process of risk analysis and risk evaluation.
Environmental risk management	Systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling environmental risk.

In association with the definitions provided, we understand environmental risk analysis to encompass the aspects as shown in Figure 2.

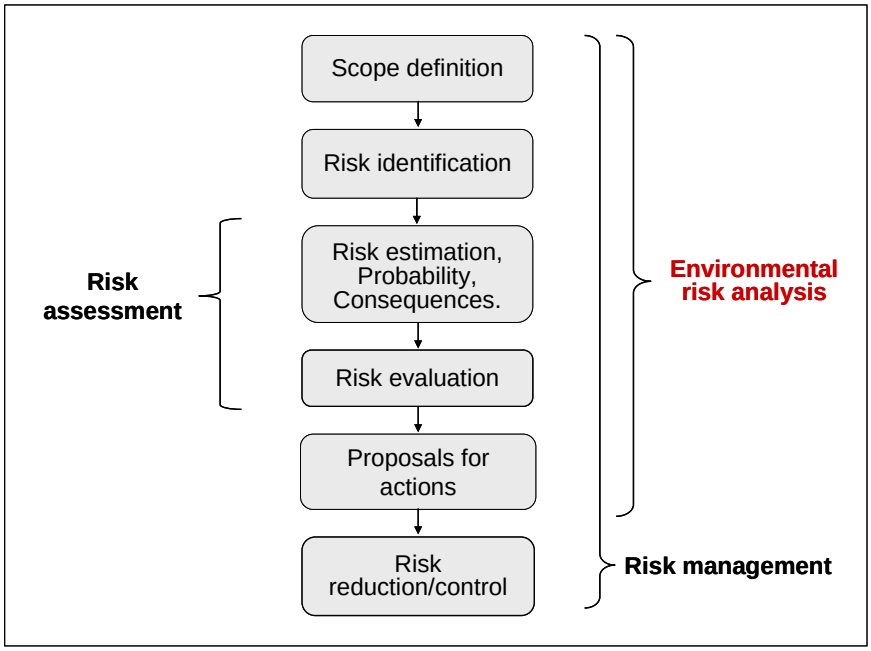

Figure 2. The content of environmental risk analysis and its relationship to risk management

4 ENVIRONMENTAL RISK ANALYSIS: STEP-BY-STEP

4.1 Scope definition

Scope definition consists of clarifying the aim of the analysis, the limits of the analysis, and the gathering of the information for planning a detailed analysis. The aim of the analysis might be, for instance, to assess the environmental risks caused by all activities on an industrial site; and may be due to the authority's demand as a prerequisite for an environmental permit, or to a requirement associated with a voluntary environmental management system.

All important background materials (such as safety reports and plans, incident statistics, and the environmental conditions – especially for sensitive areas) should be addressed in order to develop a clear preliminary risk analysis plan. A description and maps of the environment outside the industrial plant are of course important elements of an environmental risk analysis. The screening of the chemicals is an essential part of scope definition because it reveals the magnitude of the hazards related to the site studied. In the screening process it is

recommended to gather all the existing knowledge about the properties of the chemicals based not only on the safety data sheets, but also the additional information for an environmental hazard evaluation should be gathered from external sources (e.g. databases) if possible. In addition, the most significant amounts of chemicals used at the site, together with their locations, should be summarised. It is essential to notice that there may exist non-hazardous liquids such as starch which might, in a sufficiently large amount, result in a biological purification plant being shut down, and subsequently lead to other environmental hazards. As well there might exist extremely toxic chemicals which can even in very small amounts, for example, kill fish. It is suggested that all the basic chemical knowledge is gathered into one form, or table – testing of the ENVIRI guidelines showed that this is the most efficient way to make good use of the chemical knowledge in the analysis.

4.2 Risk identification

Risk identification is the stage where the employees of the process studied, together with other experts (analysis team), identify potential incidental emission situations by brainstorming. The brainstorming sessions are guided by risk analysis techniques such as "potential problem analysis". In the MS-Excel application we use a special activity and process model based risk analysis (an example of a completed activity and process model is presented in Figure 3).

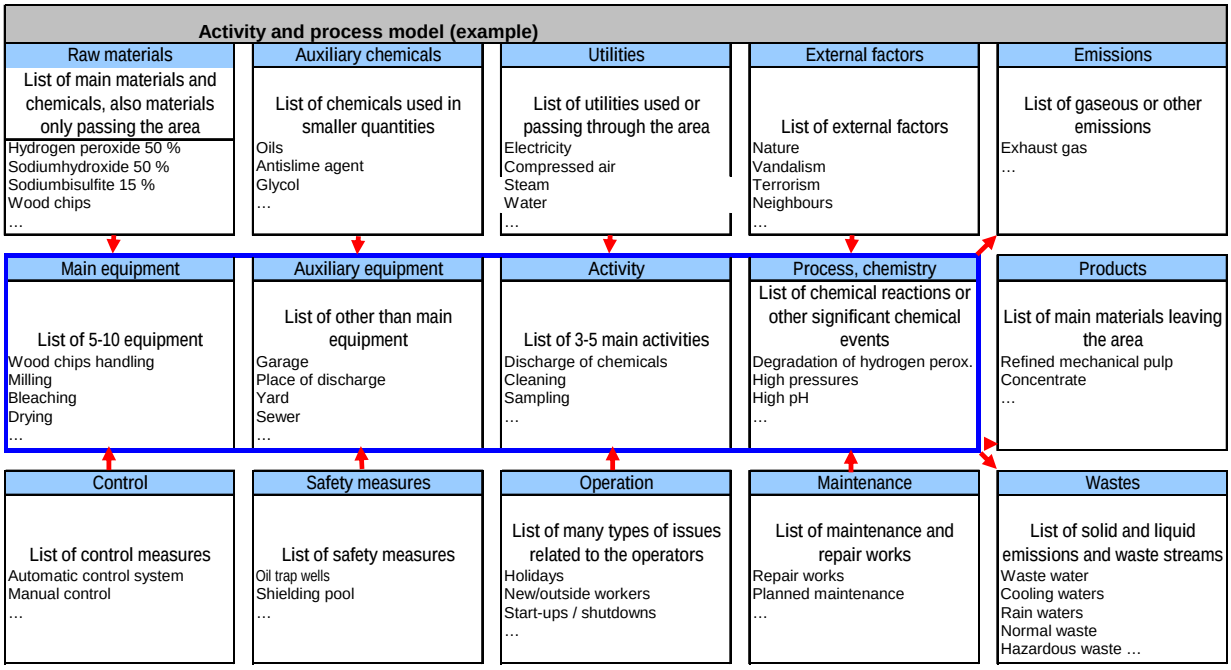

Figure 3. An example of the activity and process model. Filled model is a checklist of things where incidental emissions may occur

The activity and process model describes the process and its contents as well as all the inputs which may lead to the emissions, in other words, all the equipment and activities where incidental emissions may occur. The model is therefore a process-specific checklist, which guides the risk identification process. Each aspect is taken into discussion, with regards to whether or not an incidental emission is possible at this particular point or in this activity. The activity and process model takes into consideration the technical, human and organisational factors of the process. In that way the potential incidental emissions are discussed from different points of views, not just for instance from the technical point of view. The results of the risk identification process are recorded in the form.

The background materials gathered in the scope definition phase are useful for the risk identification phase. The tests showed that it is especially challenging to identify complicated situations that result in harm to the environment – like a fire or several unusual releases entering the biological water treatment system at the same time. This kind of dynamics and complexity must be taken into account in the discussions – the model does not do it on behalf of the personnel.

4.3 Risk estimation

Risk estimation is an iterative process where the consequences and probabilities of incidental releases are assessed and integrated. The consequences may be *ecological or societal*. In addition, they may affect the corporate image and economy. A special consequence matrix, where the consequences are classified as moderate, extensive or serious, was created in the project (Table 2). Ecological consequences may affect the air, water or soil. By societal consequences we mean the effects to the living conditions, well-being, landuse and water intake. This matrix may vary according to different country-specific situations. Table 2 is an example of a matrix designed for the Finnish environment.

Table 1. Consequence matrix – consequence categories. This matrix helps to estimate the consequences of potential incidental emissions

CONSEQUENCE MATRIX OF ENVIRONMENTAL RISK			
CONSEQUENCE	**CONSEQUENCE CATEGORY**		
	MODERATE	**EXTENSIVE**	**SERIOUS**
ECOLOGICAL Air	Harmful effects on the flora and fauna in the industrial site.	Harmful effects on the flora and fauna outside of the industrial site.	Ecosystem damage.
Soil	Limited harmful release, not transported, concentrations between target values and lower standard values. (Ministry of the Environment 2005).	Harmful release drifts less than 0,5 hectare outside of the industrial site, release is transported and/or persistent, concentrations between lower and upper standard values (Ministry of the Environment 2005).	The effects of harmful release disperse over 0,5 hectare, spatial effects difficult to assess, concentrations higher than upper standard values (Ministry of the Environment 2005).
Water	Minor harmful effects, temporary weakening of water quality in limited area; water ecology recovers the situation by itself.	Harmful releases are notable, endpoint water system is sensitive and valuable, temporary, but clear concentration peak, pollution of the coast, small amount of fish are killed, releases are persistent or rather persistent, thermal effect results in ecological changes.	Long-term and wide harmful effects, flora and fauna is disturbed, fish are killed.
SOCIETAL Health effects	Smell, vibration, health centre visits.	One or more people get an injury, which need medical care, health limit values are exceeded in the environment.	One or more people get serious injury, genotype effects, cancer, health limit values are exceeded extended in the environment.
Living conditions,			

pleasure	Harmful effects on the living conditions, but recreational use of the environment is not disturbed, temporary small aesthetic harm. Smell, vibration.	Recreational use of the environment is temporary prevented, aesthetic harm is remediable.	Recreational use of the environment is declined in large area, aesthetic harm is significant.
Land use	Polluted area exists in the industrial area, buildings get dirty, the usage of road is temporary prevented, etc.	Harmful release may disperse outside of the industrial area, e.g. to park and outdoor recreation area. Vibrations cause disturbances outside the industrial site and may damage buildings or other constructions.	Harmful release is dispersed to habitat area, cultivated land, groundwater area or to the conservation area.
Groundwater, water intake (communal or industrial)	The release does not weaken the quality of the groundwater outside of the industrial site, no harm to the water intake.	Groundwater is polluted in small area outside of the industrial site, water intake is temporary prevented.	Groundwater is polluted in large area, water intake is prevented long-term.
IMAGE	Claims and general discussion in the community and in the media about the environmental effects. Local or regional authority reacts.	Subject is on national media and news. Regional authority reacts.	Subject is on national and international media. Production infrastructure is endangered.
ECONOMY	Defined by the company.	Defined by the company.	Defined by the company.

4.4 Risk evaluation

In *risk evaluation*, the consequence and probability categories are linked in a special risk matrix; forming risk categories (Table 3, the MS-Excel application transfers the evaluation results automatically to the risk matrix). For each risk category the *proposals for actions* are determined in order to manage the risk. It is important to note that risk management performance is also incorporated in the probability categories, in addition to frequency.

Table 1. Risk matrix – risk categorisation. This matrix helps to evaluate the risks associated with potential incidental emissions

PROBABILITY		**RISK CATEGORY**		
More than once in a month, or risk management is poor.	**5**	II	I	I
More than once in a year, or risk management is rather fair.	**4**	II	I	I
More than once in 10 years, or risk management is fair.	**3**	III	II	I
Once in a lifetime of the industrial site, or risk management is good.	**2**	IV	III	II
Situation is known (sometimes happened somewhere), or risk management is excellent.	**1**	IV	IV	IV
		1	**2**	**3**
CONSEQUENCE		**MINOR**	**EXTENSIVE**	**SEVERE**

Risk category I Risk elimination extremely high priority.
Risk category II Risk elimination high priority.
Risk category III Risk elimination moderate priority.
Risk category IV Risk elimination when convenient.

4.5 Reporting

A summary of the identified and analysed environmental risks is reported to the authorities and other interest groups inside and outside of the company. The worst cases are described in more detail than the others. We recommend that also small-scale incidental emissions might be classified according to a worst case. In addition, also proposals for actions are important results of an analysis. It is also recommended to show a map of potential sources of hazards in the industrial site, and an assessment of the function of the organisation in the prevention and management of incidental releases. Also, the risk that remains after the implementation of all the preventive actions should be made visible.

In the study, it was recommended that the company keeps a record of all the incidental emissions and near miss situations, and all the incidental emissions must be reported to the authority. The authority keeps statistics of incidental emissions. Company's own book-keeping and the authority statistics give information about the status and adequacy of environmental management and the environmental safety potential of the site.

5 Conclusions

The guideline developed shows what environmental risk analysis should include and how the process of risk analysis should be conducted. The model is strongly based on the risk analysis techniques and traditions of industrial safety. A consequence matrix together with a risk matrix also helps the decision making from the viewpoint of risk tolerability and acceptance. In the guideline the environmental risk analysis process is introduced as a step-by-step procedure. The risk analysis process itself and the report of the risk analysis results is

invaluable material to the company safety performance development, and simultaneously supports environmental and chemical authorities in their work.

In future research we hope to further develop especially the assessment of cumulative effects of small incidental emissions. The procedure described here attempts to capture some of the essential elements of the risk management of socio-technical complex systems. A further challenge involves the development of the risk analysis procedure to better fulfil the demands of resilience engineering in complex socio-technical industrial systems.

It is also desirable, that the cooperation between chemical and environmental authorities will be developed so as to be more interactive, compared with the situation today.

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