Guidelines for Integrated Risk Management in Large Industrial Areas

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Abstract

This paper provides an overview of an IAEA Technical Document on Guidelines for Integrated Risk Assessment and Management in Large Industrial Areas. The document was developed over a number of years with the contribution of a large number of authors. Its main purpose is to provide guidance and a reference framework for the undertaking of integrated health and environmental risk assessment studies and for the formulation and implementation of co-ordinated health and environmental management strategies for large industrial areas, including those that accommodate energy producing facilities.

1 Introduction

There is worldwide a growing awareness and concern of governments, communities and industry about the risks to people and the environment from the location and operation of hazardous and polluting industries, including those involved in the production of energy. The identification, assessment and management of health and environmental risks are now recognized as essential elements for orderly economic and social development. This is particularly significant when dealing with an extended geographical area with conflicting demands and pressures for industrial development and urbanization.

Recognizing the importance of such needs the International Atomic Energy Agency (IAEA), the United Nations Environment Programme (UNEP) within the framework of the Awareness and Preparedness for Emergencies at Local Level (APELL) programme, the United Nations Industrial Development Organization (UNIDO) and the World Health Organization (WHO), have joined efforts to promote and facilitate the implementation of integrated risk assessment and management for large industrial areas. Such an initiative includes the compilation of procedures and methods for public health and environmental risk assessment and the transfer of knowledge and experience amongst countries in the application of these procedures.

In January 1998 the IAEA published a comprehensive report [1] with guidelines for integrated risk assessment and management in large industrial areas. The main purpose of the report is to provide practical guidance and a reference framework for the undertaking of integrated health and environmental risk assessment studies and for the formulation and implementation of co-ordinated health and environmental management strategies for large industrial areas, including those that accommodate energy producing facilities. This purpose is achieved by presenting an outline of the methodologies and procedures to enable an appreciation of the techniques and processes involved. The integrated risk assessment approach, however, necessitates a cumulative approach for all emission sources, over the entire cycle of production for a number of industries and associated operations including transportation and waste generation. The integrated risk management approach also necessitates the formulation of overall co-ordinated strategies involving multi-dimensional elements including technical, locational, social and economic considerations. These aspects require specialized methodologies. The guidelines therefore refer to existing documentation where appropriate, but in addition provide specialized guidance to address the integrated risk assessment approach on an area-wide basis.

The guidelines address the following topics: project management; hazard identification and prioritization; analysis and assessment of continuous emissions from fixed facilities; analysis of accidents from fixed facilities; assessment of transportation risk; analysis of hazardous wastes; risk management; international legislation.

2 Project management

There are a number of facets in which an integrated area-wide risk assessment project differs from other projects. Firstly, the number of parties involved is relatively large and therefore, a description of the project and the organizational and management aspects thereof require particular attention. Usually, the project deals with complex issues that could be socially and politically sensitive. Debate may ensue as to the results of the assessment and the proposed risk management recommendations; extra care is therefore required in formulating both. The uncertainty associated with the end results may be great, since assessment of the health and environmental risks relies on a number of assumptions. Therefore the quantified results should be interpreted with care and all the uncertainties exposed. To ensure orderly and efficient progress of the study a number of procedural steps should be followed:

Step 1: Establishment of a Database for the Study Area and Prioritization of Activities for Analysis. This includes the delineation of the study area, the identification of various land uses, nature and type of industrial and other activities, the identification of priority activities for analysis and the

establishment of key environmental and safety issues. An initial hazard identification scheme in order to determine those facilities for further analysis may be adopted.

Step 2: Conduct of Health and Environmental Risk Analysis Studies. This includes: Quantified Risk or Hazard Analysis (QRA) for major accidents, analysis of continuous emissions and quantification of environmental impacts from emissions into air and water, analysis of hazardous waste generation and analysis of transportation related risks.

Step 3: Conduct of Infra-structure and Organizational Safety Analysis. This includes the analysis and evaluation of emergency planning provisions, including prevention and protection facilities off-site and on-site; environmental monitoring infra-structure in the area; and the review and analysis of institutional and regulatory provisions.

Step 4: Formulation of Integrated Management Strategies with Associated Action Plans. This includes the establishment of cost/benefit allocations for the various risk contributors and the prioritization of implementation measures. The components of the risk management strategy should cover the technical, operational, organizational and locational aspects.

3 Hazard identification and prioritization

The crucial first step in an area-wide risk assessment and management project is the delineation of an appropriate study area. The appropriate basis for area selection will depend on the particular circumstances of each case. The study area is defined as the area where the emissions from the industrial area may significantly affect human health and the environment. Although absolute rules for choosing a study area cannot be given, experience on the dispersion of pollutants through different media will help to define the study area. Several factors should be considered:

- The study area should be selected for its physical and industrial/economic characteristics, although administrative and national boundaries may be used if necessary.
- Strict boundaries should not be drawn before the initial hazard analysis is completed, as the area which may be affected will not have been identified.
- Transport systems for the movement of hazardous materials should only be considered within the study area.
- Some risk sources will have potential for effects well beyond the immediate area. In certain cases consideration should be given to see if

the analysis needs to take account of local effects and separately of wider regional effects. Community concern may also be considered.

In some situations it may be possible, and more expedient, to use the procedures described in the Manual for the Classification and Prioritization of Risks from Major Accidents in Process and Related Industries, [2]. The methods and procedures outlined in the manual apply to the risks of major accidents with off-site consequences from fixed installations handling, storing and processing hazardous materials; and transport of hazardous materials by road, rail, pipelines and inland waterways. The types of risk being considered are risk of fires, explosions and releases of toxic substances to the public outside the boundaries of hazardous installations. The risk to workers (occupational risk) and the risk of accidents to the natural environment are not included.

4 Analysis and assessment of continuos emissions from fixed facilities

Emission sources have to be characterized and compared with the relevant emission standards concerning air, water and soil pollution. As far as the effects are concerned, once the receptors have been identified, the transport of the pollutants from the source to the receptor has to be defined and calculated and the dose-response relationships to the receptor assessed. Owing to the probabilistic character of the transport process, exposures to the receptors are obtained in terms of figures with probabilities. The estimated risk to the receptor, i.e. certain damage affected by a certain probability, is calculated and compared with the relevant risk acceptance criteria. If the criteria are not met, the pollution abatement process in the plant has to be adapted in an iterative procedure.

The first step in analyzing continuous emissions is to identify their sources and to characterize their quantities and their physical and chemical properties.

The second step is to identify receptors and characterize the dispersion of pollutants from source to receptor, either through the use of mathematical models or the use of measurements if available. The procedure requires that receptors, be they human populations or sensitive environments, be identified and located, and pathways from source to receptor be determined. Appropriate models are then established and exposures estimated. Ambient monitoring of pollution levels is helpful in guiding this process and in validating results of modeling. Modeling the transport of pollutants from source to receptor provides an estimate of exposure.

The next steps are meant to identify or develop dose-response relationships between exposure and effects so that effects or risk may be determined. An overview of the relevant environmental guidelines and standards is also given in

the report.

5 Analysis of accidents from fixed facilities

Good industrial safety practices, engineering safety codes and standards, design and operating procedures remain at the core of safety management. The increasing awareness of hazards and accidents, that may result in a significant loss of life and property, has led to development and application of systematic approaches, methods and tools for risk assessment. These methods termed "quantified risk assessment" are hazard evaluation tools. The risk assessment process involves: a system description, the identification of hazards, the development of accident scenarios and events associated with a process operation or a storage facility, the estimation of the effects or consequences of such hazardous events on people, property and the environment, the estimation of the probability or likelihood of such hazardous events occurring in practice and of their effects - accounting for the different operational and organizational hazard controls and practices, the quantification of ensuing risk levels outside the plant boundaries in terms of both consequences and probabilities, and the assessment of such risk levels by reference to quantified risk criteria.

There are a number of uncertainties associated with the quantification of risk. The report provides guidance on the quantified risk assessment process including the process of combining accident frequency and consequences to express individual and societal risks. The risk assessment process should in all cases expose and recognize such uncertainties.

6 Assessment of transportation risk

An increasing number of transportation accidents involving hazardous substances have occurred worldwide. Such accidents with their resultant effects on people and the environment have increased awareness in government, industry and the community at large and resulted in a re-think in the risk assessment process for hazardous substances transportation.

There are several important features of transport risk that require a different type of analysis to fixed facilities. Such features include: the hazard source is not continuously present at any place (except pipelines) and the exposed population is in close proximity to the hazard.

This chapter of the guidelines focuses on the analysis and assessment of transportation routes (road, rail, waterway, harbour and pipelines) for the carriage of hazardous materials. The integrated risk assessment approach to the safety of hazardous substance transportation necessitates consideration of its main elements in an integrated manner. The three elements are: transportation risk and environmental and land use safety factors**;** capability of the existing

network and cumulative traffic implications**;** and economic distribution considerations and operator's requirements for practical transportation economics.

An integrated assessment of the safety adequacy of an existing hazardous substances transportation route or the formulation of alternative routes for the safety management of such transportation necessitate the quantification and weighing of all three elements indicated above. Focus of the guideline document is on the risk and environmental considerations of hazardous material transportation. An example is given of the analysis and assessment of the transport operational and traffic factors for a road route.

7 Analysis of hazardous waste

Wastes are generated by almost all branches of industry including industries that produce non-dangerous products, but a few major groups are most likely to produce hazardous toxic wastes which require special treatment. Industries with a high potential for generating hazardous wastes are mainly: inorganic and organic chemicals, petroleum refining, iron and steel, non-ferrous metals (smelting and refinery), leather tanning and finishing, paint and coatings, nuclear facilities, electroplating and metal finishing. A list of the main waste producing industries, the type of waste produced and the potential impacts on health and the environment is presented in the guidelines.

The various points at which the generation, storage, handling and transport of hazardous wastes may arise and the hierarchy or alternatives in waste management are illustrated. Four options are discussed: avoidance at source; re-cycling of the hazardous waste; special treatment of hazardous waste; and disposal of the waste.

It is not only industrial wastes that need to be considered in the integrated risk assessment of the study area concerned but also domestic wastes such as discarded paints, insecticides and aerosol containers can be hazardous and in landfill disposal sites methane may be produced which can present an explosion hazard. Toxic chemicals can also get into ground-water if not properly contained.

The assessment of the risks from all the waste forms produced in a large area of industrial activity will be very difficult and time-consuming and it is recommended that a top-down approach is applied to rank the wastes in order of priority so that those which cause the biggest problem can be identified and dealt with first.

8 Risk management

The objective of this chapter is to provide guidance in the preparation and presentation of the final report, to assist with setting decision criteria and to help in the preparation of remedial action plans.

Risk management constitutes a system of decisions directed towards what needs to be done in order to reduce unacceptable risks. The problem of choice is in most cases based on economic analysis and every economic analysis is reduced to the question of the optimal utilization of financial resources. Thus, risk management itself is reduced to the problem of selecting risk reduction/elimination measures to bring about maximum risk reduction with the available means.

The following steps are distinguished in the area risk management: definition of decision criteria for the identified risks in the risk analysis; decision analysis on the defined alternative options; presentation of the results of the decision analysis for the decision makers and the public.

The above mentioned steps are iterative. One will start defining the decision criteria for the acceptable or tolerable risks. Next it will be assessed if in the present situation (or for the proposed development) the criteria are met. If not, different packages of risk reducing measures will be defined and assessments made on which packages meet the criteria, including the costs of these packages. The result will be that some packages meet the criteria at acceptable costs, other packages at high costs and some do not meet the criteria. It is possible that not one package meets the defined criteria at acceptable costs. Then it will be necessary to set less rigid criteria and the decision analysis can be repeated. With proper risk management and additional risk reduction measures, the risks of industries or transport of hazardous materials can be reduced.

It is widely recognized within the process industry that safety management systems have a major influence on failure rates. It has been frequently demonstrated that dramatic improvements in Lost Time Injury rates are possible by large corporations which have adopted rigorous and auditable safety management procedures. Given the very large impact of Safety Management Systems (SMS), there is increasing belief by regulatory bodies in the need to quantify such systems and to consider these in an analogous manner to hardware implications in QRA studies.

9 Review and development of legislation

The final chapter provides an overview of the legislative requirements in selected countries in the field of major hazards control. The main aim is to highlight the relevant practices. The formulation of a specific regulatory framework is a matter for each national authority to consider, based on local circumstances.

Legislation about safety at work and accident prevention exists in all countries. This legislation aims to protect primarily the workers in industry, but at the same time also to contribute to the safety of the population and the environment. Usually this legislation does not regulate in terms of risk, but may contain technical specifications which sometimes require risk assessments to satisfy the authorities that the necessary margin of safety does exist.

In the last twenty years, however, this legislation has resulted in not being completely satisfactory. Therefore, a new type of legislation is being developed which is based on the probabilistic notion of risk and aims to reduce the risk of industrial activities.

References

1. Guidelines for integrated risk assessment and management in large industrial areas. IAEA-TECDOC-994, IAEA Vienna, 1998.

2. Manual for the classification ad prioritization of risks due to major accidents in process and related industries. IAEA-TECDOC-727 (Rev.1), IAEA Vienna, 1996.