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Report of the OECD Workshop on Risk Assessment and Risk Communication in the Context of Chemical Accident Prevention, Preparedness and Response

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Report of the OECD Workshop on Risk Assessment and Risk Communication in the Context of Chemical Accident Prevention, Preparedness and Response

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to chemical accident prevention, preparedness and response include:

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The work of the OECD related to chemical accident prevention, preparedness and response is carried out by the Expert Group on Chemical Accidents, with Secretariat support from the Environmental Health and Safety Division of the Environment Directorate. As part of its work on chemical accidents, the OECD has issued several Council Decisions and Recommendations (the former legally binding on Member countries), as well as numerous Guidance Documents and technical reports including the OECD *Guiding Principles for Chemical Accident Prevention, Preparedness and Response*; *Guidance Concerning Chemical Safety in Port Areas; Guidance Concerning Health Aspects of Chemical Accidents*; the joint IPCS/OECD/UNEP/WHO publication, *Health Aspects of Chemical Accidents*; and the joint OECD/UNEP *International Directory of Emergency Response Centres* (currently being revised by the OECD and UNEP IE).

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This publication was produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC).

This publication is available electronically, at no charge.

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The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) was established in 1995 by UNEP, ILO, FAO, WHO, UNIDO and the OECD (the Participating Organizations), following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organizations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

Foreword

The OECD Workshop on Risk Assessment and Risk Communication in the Context of Accident Prevention, Preparedness and Response took place on 11-14 July 1995 at the OECD's headquarters in Paris. It was sponsored by Spain, and co-sponsored by IPCS (the International Programme on Chemical Safety), UNEP IE (the United Nations Environment Programme's Industry and Environment centre) and WHO-ECEH (the World Health Organization – European Centre for Environment and Health), in co-operation with UN ECE (the Economic Commission for Europe).

The Workshop provided an opportunity for a wide range of government officials, and representatives of other stakeholders, to share ideas and experiences concerning the assessment and communication of risks related to chemical accidents. It focused on practical aspects of choosing risk assessment approaches, and on the application of assessments and the communication of results.

This report presents the Workshop's Conclusions and Recommendations, as well as three discussion documents prepared for the Workshop. The discussion document on risk assessment was revised to take account of the comments and views of Workshop participants.

There is a brief description, at the end of the document, of further work on risk reduction being undertaken in the OECD in the context of chemical accident prevention, preparedness and response.

The OECD's Joint Meeting of the Chemicals Group and Management Committee of the Special Programme on the Control of Chemicals recommended that this document be derestricted. It is published on the responsibility of the Secretary-General of the OECD.

Table of Contents

Conclusions and Recommendations of the Workshop 11

Risk Assessment 11

Risk Communication...20

Discussion Document on Risk Assessment
Miles A. Seaman... 25

Discussion Documents on Risk Communication..61

Considerations and Principles for Risk Communication for Industrial Accidents
Roger Kasperson and Jeanne X. Kasperson...63

Communication with the Public: Risk Management and Worst Case Scenarios: The Kanawha Valley Experience
Richard N. Knowles and L. Craig Skaggs..91

Further OECD Work on Risk Assessment in the Context of Chemical Accident Prevention, Preparedness and Response 101

CONCLUSIONS AND RECOMMENDATIONS OF THE WORKSHOP

RISK ASSESSMENT

Conclusions

1. The Workshop recognised that risk assessment is an essential component of the overall management of risks within society, and specifically risks to human health and/or the environment. It is important to recognise that there are many stakeholders in society with an interest in the process of assessing risks in the context of chemical accidents and, in particular, in the outputs of risk assessment. Risk assessment should not, therefore, be viewed as a narrow technical activity. Rather, risk assessment combines elements of toxicology, engineering, environmental sciences, and statistics. When risk assessments are used as part of the decision-making process, they can be utilised in combination with elements of economics and psychology, often in a political context.

2. The importance of risk assessment to decision-making for all stakeholders, and its multi-faceted characteristics, are factors which lie behind the Conclusions of the Workshop and the Recommendations for further actions which are presented below.

3. Risk assessments serve many ends and the risk assessment process is used for a variety of "purposes/objectives" related to prevention, preparedness or response. They are used in practically every step of the so-called safety chain: proaction (setting policy, prioritising action, weighing alternatives, and making decisions about permitting dangerous activities or nearby developments); prevention; preparedness; response; and recovery (including health care). Governments use risk assessments, *inter alia*, to frame regulatory controls, for land use planning and in emergency preparedness. Management of hazardous installations use risk assessments for, e.g., setting policy, ranking risks, prioritising action, and weighing options. While the focus of the Workshop was on fixed installations, risk assessments are also used in the context of transport of hazardous goods in the context, for example, of priority setting, consideration of alternative approaches and the development of concepts of "acceptable" risks.

4. The way risk assessment is used influences the relative importance of uncertainties which are part of the risk assessment process. The use of less rigorous, more generic approaches or the use of comparative assessments when choosing among alternatives are examples of decision-making processes where uncertainties are of less concern. For risk assessments to be as effective as possible, those conducting the assessment should understand the context in which the assessment is being made.

5. The value of the assessment can be evaluated by using criteria such as: the completeness/comprehensiveness of the information (are all relevant risk dimensions considered); the correctness of information (relating to uncertainties, the quality of the analysis); the practicality of the

assessment (can the results be used in real life); and the ability of the assessment to enhance insight and understanding, leading to discussion among stakeholders.

6. All risk assessment approaches and methodologies have strengths and weaknesses. Indicators of the factors that might influence the choice of a particular approach/methodology are related to, *inter alia*, the objectives of the risk assessment, the adequacy of data, the availability of expertise and resources, and the socio-political context of the risk assessment activity.

7. The limitations of data available to risk assessors is a fundamental obstacle to the development of more robust risk assessments. There are gaps and inadequacies in the data available on, *inter alia*, equipment failure rates and modes, human error predictions, long-term or delayed health effects of acute exposures (as well as short-term effects), and the effects of chemicals on the environment. It was recognized that the use of death as the sole parameter for the measurement of consequences in the risk assessment process may result in misleading or otherwise inadequate conclusions, depending on the types of decision which have to be made. The use of concepts such as dangerous dose or information on nuisance (odour), irritant, incapacitating dose or irreversible effects dose as a measure of consequences was considered to be appropriate in some situations. However, it was noted that the lack of such data often results in the necessity of using mortality as a consequence measurement.

8. In order that risk assessments are appropriately utilized in decision-making processes, decision-makers should be informed about the assumptions, limitations and uncertainties imbedded in the risk assessment process as well as the implications of these in the decision-making process.

9. As described further in this document, risk assessment should be recognised as a process which consists of a number of "steps". Numerous different models for undertaking the risk assessment exist. While there is great diversity in the detailed approach and methodologies used in different countries/organisations, risk assessments share some common characteristics. The essential steps of risk assessments include, e.g.: defining the purpose of the assessment; hazard identification, including information gathering; an estimation of consequences and frequencies; a characterization of risk; and an evaluation of the significance of the results, which then forms an input to a decision-making process. The results of the risk assessment process are called "risk assessments". It should be recognised that the public has a role in the process, particularly with respect to the evaluation of the significance of the results.

10. To carry out each step in the risk assessment process, there are a number of alternative "approaches or methodologies" available. The choice of the alternatives is dependent on a variety of factors or "indicators". In this regard, the thoroughness of (and the resources allocated to) the risk assessment process is generally in proportion to the magnitude of the estimated risk.

11. Risk assessment is a continuous and evolving activity. It must be reviewed in the light of specific triggers such as process changes, developments around sites, new data on the effects of substances, etc. Furthermore, risk assessments should be reviewed routinely, without specific triggers, to test assumptions and try to resolve uncertainties. Improvements in risk assessment methodologies should be sought and utilized. It is, however, obvious that within the risk assessment process some assumptions cannot be eliminated. In such cases it is advisable to seek consensus about assumptions that have to be made with all the parties who are involved in the decision-making process.

12. A lack of consistency in the definitions of key terms is an impediment to understanding amongst countries and amongst stakeholders of the approaches/methodologies used for, and the significance of the results obtained from, risk assessments.

13. Transparency in the risk assessment process is essential. The decisions that are influenced by risk assessments are of fundamental importance to all who might be affected, especially workers, the public immediately outside the installation, and emergency response personnel. Considerations of particular concern include potential effects on their health, environment, property and economic interests. The stakeholders need to be aware of the strengths and limitations of the risk assessment process and the approaches/methodologies used. Where possible, they need to be involved in the process, which builds confidence in the results and facilitates open and constructive dialogue.

14. There is a close link between the risk assessment process and emergency planning. Risk assessment is used to take into account the potential consequences of an incident for, *inter alia*, workers, the public, emergency services and the environment. In this regard, risk assessment provides a basis for identifying activities which pose unreasonable risks to workers. Furthermore, there is a link between risk assessment and emergency response in order to control the event or mitigate its adverse effects. Risk assessment also helps to establish an inventory of risky activities.

15. As indicated, currently most risk assessments tend to focus on lethal effects, but this is strongly influenced by the context in which the assessment is done (e.g., relating to health effects, major accidents, etc). It is accepted that the risk assessment process should also take account of possible health (sub-lethal) and environmental consequences (e.g., as recognised in environmental impact studies). Further work is needed to develop or adapt appropriate criteria, approaches and methodologies to take account of sublethal and environmental consequences.

16. Cost-benefit analysis (CBA) is a risk assessment approach which can help decision-making by a number of stakeholders. Companies can use CBA to inform the allocation of resources, to ensure that the health, safety and environmental benefits of a given amount of expenditure are maximized. Governments can use CBA to assist decisions on the scope and nature of regulatory controls. The cost-benefit analysis can also address distributional risk, so that equity impacts and social justice questions are not overlooked (and are indeed clarified). However, there are difficulties with the methods used to assess the benefits of actions, to assign a value to life, injury, illness and environmental damage, and to select a discount rate when considering inter-generational effects.

17. In summary, the Workshop participants recognised the difficulties in communication and sharing of experience which results from the differences in the way that terminology is used in different countries and organisations. It was concluded that standardisation of the risk assessment process, and approaches/methodologies used in each step of the process, is neither desirable nor feasible. Nonetheless, enhancing the mutual understanding of risk assessment in the context of chemical accidents can be furthered by, e.g., efforts to map out the steps in the risk assessment process and the approaches/methodologies used therein and an elaboration of the indicators influencing choices of particular approaches/methodologies. It must be emphasized that this is not intended to direct, still less to prescribe, a particular approach. The objective of these efforts should be to help stakeholders see more clearly the range of possibilities and to assist them in decisions which only they can make. It may be useful if the improved understanding can lead to a consensus in certain technical aspects of risk assessments.

Recommendations

18. It is recommended that a thesaurus of terms related to risk assessment be developed. This would not seek to harmonize definitions but, rather, would clearly indicate what the terms encompass and how they are used.

19. It is recommended that the risk assessment process be mapped out in a generic way. In addition, the detailed approaches or methodologies for the different steps should be described so that stakeholders can see the range of possibilities open to them, characterize their risk assessments, and better understand the work and result of others.

20. In order to assist in the choice of risk assessment approaches/methodologies, it is recommended that indicators be elaborated, along with an idea of their linkages to approaches/methodologies. This will be useful for all stakeholders, in particular for small and medium-sized enterprises, new installations, countries in transition and developing countries, in order to identify those approaches/methodologies most appropriate to their circumstances.

21. It is recommended that a Workshop be held to consider issues related to the use of environmental and non-lethal health consequences in risk assessments. It is recommended that the OECD undertake efforts to improve the quantity and quality of data on the environmental and non-lethal health consequences of accidents, and support the efforts of others, such as IPCS and WHO, in the area of health consequences.

Elaboration of Conclusions and Recommendations concerning Risk Assessment

Terminology

22. Understanding among countries and among stakeholders about the concepts of risk assessment is crucial to the future development of the subject. A barrier to greater understanding of the approaches/methodologies for, and results of, the risk assessment process is the use of terms that have several meanings. The roots of the differences sometimes lie deep within national languages, culture and legislation and these differences will not be resolved, even in the longer term. Furthermore, engineers, toxicologists, environmental scientists, social scientists, accountants, lawyers, businessmen, trade unions, insurers, politicians, pressure groups and the public also might attach different meanings to key terms.

23. It is too ambitious to standardise usage across all these stakeholders. It is feasible to develop a thesaurus which would lay open the different meanings. This process might also reveal where the differences are at the conceptual or semantic level. For instance, it may be that hazard and risk are expressed slightly differently, but there is a shared notion that, at heart, hazard embodies the notion of an inherent attribute for harm whereas risk adds to that a notion of likelihood and expected frequency.

24. It is therefore concluded that a greater shared understanding of the different usages of key risk assessment terms and the concepts which they give expression to is essential, and it is recommended that a thesaurus be developed for this purpose. In addition, it was concluded that communications related to risk assessments should include a description of how terms are used in the specific circumstances.

The Risk Assessment Process

25. Risk assessments are used for a broad range of purposes/objectives. At one level, it is something that we all do daily, albeit unsystematically, in order to navigate a safe path through life. At another extreme, it is a highly structured, complex, resource-intensive activity providing an input to a major societal decision, e.g., whether and where to build a nuclear power station. This illustrates an important feature of risk assessment: its diversity. There are widely different specific approaches/methodologies. The factors which influence the choice and use of a particular approach/methodology are considered later.

26. While there is diversity in the detail, there are some common unifying elements of risk assessments. A working definition of a risk assessment might be: an identification of hazards and an estimation and characterisation of the risks arising from them with a view to their prevention, mitigation and/or control or to a comparison of risk.

27. Risk assessment is a process that has a number of sequential essential steps. The approaches/methodologies used to carry out each step are not, and need not be, uniform. For instance, some steps might be undertaken using quantitative or qualitative techniques. HAZOP, HAZAN, fault tree analysis, failure modes analysis, and computer modelling techniques for toxic substance releases might be used. There is also a place for checklists and qualitative "what if" approaches. The risk assessment process should also include the analysis of available data on past accidents and the lessons learned.

28. The choice of a particular approach/methodology is governed by a number of indicators, including:

- the objectives/purpose of the risk assessment;
- the estimated magnitude of the risks;
- the availability and adequacy of the data;
- the expertise needed for a particular approach/methodology;
- the resources which are appropriate to the objective and those which can be drawn upon;
- the time constraints on the process; and
- the socio-political context in which the assessment is carried out.

29. A deeper understanding of each of these indicators will help all stakeholders to be aware of the constraints which attach to the risk assessment process, and it will aid in the selection of appropriate methodologies for particular applications.

30. Audit and review are critical to the risk management cycle and to the risk assessment process itself. They provide the link that makes risk management a continuous activity by checking conditions and challenging assumptions, which then may lead to changes in policy or objectives. Risk assessment must similarly be considered a continuous and evolving process. There are some clear criteria for revisiting a risk assessment. These include:

- where there are new or changed processes at hazardous installations or where there are significant changes in transport;
- where incidents occur;
- where new technology offers scope for improvements;
- where the experience of workers and management is at odds with the risk assessment;
- where new information about the behaviour or effects of substances and processes becomes available; and
- where there are proposals for building/development on or near the installation or, in the case of a risk assessment for transport route, where there are proposals for significant developments nearby.

While these specific triggers for a re-assessment can be identified, all assessments should be periodically reviewed. All risk assessments, even those which are quantitative, rely on assumptions and are surrounded by uncertainties. Re-appraisal is needed to check the validity of assumptions, to try to resolve uncertainties, and to take advantage of experience and improvements in methodologies.

The Objectives of Risk Assessment

31. It is an axiom of good management that success is likely only where objectives are clearly stated. This also applies to risk assessment. It can fulfill several purposes. A clear statement of objectives for any risk assessment activity is needed, so that an appropriate risk assessment tool can be selected.

32. Risk assessment is not an end in itself. At one level, it is an input to a broader process of the management of risk within industry and government at various levels. Risk assessments can feed into the elements of this risk management cycle, such as the establishment of objectives and targets, development of policy and procedures, and audit/review activities.

33. With respect to policy, risk assessment provides information to policymakers to help them develop risk acceptability or tolerability criteria. A policy can give qualitative or quantitative expression to such criteria, which then form the benchmark against which specific objectives or programmes are assessed. This can be done by various stakeholders, at different levels. The setting of such criteria is a complex process and is strongly influenced by the socio-political context.

34. Fundamental questions such as what risk is acceptable should be addressed by all stakeholders. Stakeholders should come together and agree on acceptable risk on a case-by-case basis. This process can be greatly helped by having an agreed framework for judging acceptability, which has wide application in many contexts. Risk assessment can inform this decision-making process but is not, and should not be, the sole decisive influence. Such questions are a matter of socio-political judgement.

35. The fact that those who assess risks are often different to those who make decisions affecting risk management is a key factor in dictating the need for transparency in the risk assessment process and a shared understanding of the concepts which underpin risk assessment terminology.

36. Risk assessment can also inform the selection of prevention and control strategies. The essential benefit of all risk assessment methodologies is that they bring a structure and an analytical approach to assessments which might previously have been undertaken intuitively and unsystematically. The very process of doing a risk assessment can reveal weaknesses and expose faulty assumptions about the effectiveness and appropriateness of existing control strategies. Risk assessments can therefore be powerful instruments in continuous improvement programmes.

37. Risk assessment can also be extremely useful in choosing between options and setting priorities for action. In any organisation, resources are finite and decisions have to be made on where a given expenditure will produce the greatest reduction in risk. Risk assessment is a tool which enables risks to be ranked and options evaluated so that the benefits of expenditures are maximised. Cost-benefit analysis, in particular, seeks to weigh the health, safety and environmental benefits of an action against the costs incurred by that action. But there are problems with quantifying benefits, and there may be unease about assigning a monetary value to life, injury, illness and environmental damage. Furthermore, costs and benefits are not equally distributed throughout society.

The Adequacy of Data

38. The quality and robustness of a risk assessment is crucially dependent on the adequacy of the data on which it is based. The lack of data or doubts about its accuracy and validity are major obstacles to improving risk assessment. Inadequacies and gaps exist in the following areas, *inter alia*:

- equipment failure modes, failure rates and event frequencies;
- human error;
- the fate/effects of chemicals released into the environment;
- the long-term or delayed health effects of acute exposures, as well as the short-term effects;
- environmental effects and health consequences related to environmental degradation; and
- variations in an individual's susceptibility to toxics, heat and explosion forces.

39. A particular benefit of improved data on environmental and health effects will be to enable more use to be made of the concept of "dangerous dose", rather than the crude measure of death as a risk assessment parameter.

40. It was also recognized that data limitations can be managed, in part, through the use of less detailed, more generic approaches/methodologies or the use of comparative assessments when choosing among alternatives. The use of comparative assessments normally involves similar assumptions, limitations and uncertainties and therefore their effect on the assessment results is dissipated.

41. The need for the further development of approaches/methodologies, particularly in the area of environmental consequence estimation, was recognised.

The Availability of Expertise and Resources

42. There are gaps in knowledge, and a limited number of experts knowledgeable in risk assessment techniques and especially in the use of more sophisticated quantitative risk assessment techniques. This has two major implications. First, it indicates a need for a transfer of knowledge and experience between countries and between organisations. Second, it indicates that it would be a mistake to recommend the use of specific approaches/methodologies which require the use of expertise which is not widely available except in special circumstances.

43. It is recommended that countries and organisations improve the exchange of information so that competence in the use of risk assessment approaches/methodologies is enhanced. Such information exchange can also be used to facilitate training in order to increase the expertise available. In general, a conscious effort should be made to train assessors in order to ensure continuing competence.

44. The fact that risk assessment can be a resource-intensive activity influences the use of particular methodologies. In some situations resources might be an overriding constraint. But in most cases there will be a link between the resources for risk assessment and the significance of the assessment for a

decision or process. Having clear objectives for the uses of the risk assessment will help ensure that the allocation of resources to the process is properly considered.

The Socio-Political Context

45. It has been recognised that the approach to risk assessment and the use to which it is put will be strongly influenced by the socio-political context. This can be characterized by a spectrum from systems which favour a deterministic approach, based on standards, through to those which adopt a probabilistic approach. But such an analysis might be too simplistic. Even within a single national system detailed approaches might be more, or less, deterministic or probabilistic depending on the specific application. Thus, risk assessment might be used for novel processes but there might, in the same system, be a heavy reliance on standards for very well-established processes which have had many years' operating experience. It was concluded that the socio-political context is an overriding influence on risk assessment approaches, and it is recommended that this fact is kept in the forefront during any future work on this subject.

RISK COMMUNICATION

The problem with communication is the illusion that it is complete.

G.B. Shaw

Conclusions

46. Risk communication can be defined as any purposeful exchange of information about risks.

47. The term "risk communication" has been used differently in different contexts. In some cases, it is used to mean only access to information or a one-way communication. In a more comprehensive context, it involves a two-way transfer of information and in some cases includes direct involvement in the risk assessment and decision-making processes. It was recognized that in the context of chemical accidents, all stakeholders have something to offer and something to gain and, therefore, the objective of risk communication should be a two-way process based on openness and trust.

48. Risk communication is a very complex process with strong psychological undertones, which hinges on the purpose for which it is being undertaken, the setting in which it will take place, the cultural and technical environments surrounding it, and the key stakeholders who may be involved. Examples of different situations that could affect the risk communications strategy that is developed include:

- Is it in support of a new plant site or an existing one familiar to the community?
- Is it to provide information following a serious chemical accident?
- Is the setting urban or rural?
- Is it part of a continuous improvement programme or a new situation?

49. Risk communication forms an important, perhaps a vital, element in the risk management process. Most countries have mandated that information about chemical risks must flow to the public, and some guidelines have been produced. However, at this time the considerable experience that has been gained has not been collected and organised in a comprehensive form to provide guidance and assistance to users. Some areas where help would be particularly welcome were discussed, including: How are key stakeholders identified? What are the common pitfalls and how can they be avoided? and What are some of the techniques of successfully communicating about risks in different situations?

50. Important elements in any risk communications process include, for example:

- the identification of key stakeholders (this may include plant employees, representatives of the local news media, community leaders, members of the health community, academics, schoolchildren, representatives of religious groups, persons with special interests, and others);

- ways to take account of the needs and interests of the various stakeholders from multi-faceted communities concerned with economic as well health and environmental consequences);

- the identification of the objectives of the process and the needs of the various stakeholders;

- fostering an interactive flow of information among stakeholders;

- approaches to facilitate the development of trust and credibility; and

- the use of techniques to help people reach a common understanding of risk, recognising that the public often perceives risk differently than do experts.

51. An effective risk communication programme requires an understanding of the real issues and concerns of stakeholders and a demonstrated willingness to address them. The issues and concerns need to be identified through research directly involving stakeholders.

52. Rarely will the public's concern be limited solely to information about chemicals, but may include much broader risk management issues. A responsive communications programme will probably require the company to share information about a wide range of company activities, some not directly related to hazardous substances. The link between an open, responsible attitude on the company's part and a successful risk communication programme with the community cannot be underestimated.

53. Risk communication experience indicates that the process can be highly beneficial in creating a group of well-informed stakeholders and in improving preparedness and response, which may help reduce the risk from hazardous activities. Experience also suggests that industries which effectively involve the public and other stakeholders make significant reductions in risks. A successful communications experience can result in better integration of the hazardous site into the community and promote strong ties among groups that may have to co-operate in an emergency situation.

54. Workshop participants agreed that it is difficult to define and measure "successful" risk communication programmes. They identified a number of factors that could contribute to success. These include, among others: early and continuing involvement of the public (don't wait until an accident happens); responsiveness to questions and concerns; support from the upper management of installations; open relationships with representatives of the media; provision of clear and simple explanations of risks and their implications for the community; making connections with individuals, including critics; and engagement of a broad range of parties (including those not normally considered, such as students). These factors are considered in more detail in the following paragraphs. Furthermore, communication of information concerning emergency plans and actions to take in the event of an accident should be reinforced through the involvement of the stakeholders in preparedness activities such as exercises and simulations.

55. In connection with improved risk communication, in many OECD countries there has been a movement away from a "command and control" or "top-down" management style at hazardous installations in favour of a more open, participative and co-operative mode, in particular in dealing with the community and the various concerned groups. This has implications for staff training programmes throughout the company. Trustful, credible relationships with the community may be made more difficult because of the fact that some modern societies hold corporate and government officials in low esteem.

56. The move towards the clear and consistent understanding of the use of risk terminology, as well as an improved characterization of risk and articulation of its supporting scientific data, will benefit risk communication. Care must be taken to express complex technical information in clear, easily understood language that will facilitate communication and build trust with stakeholders. Much work remains to be done in this area, and there was a sense throughout the Workshop that it should be undertaken as expeditiously as possible and that the results of this work should be put in the hands of risk communicators quickly.

57. The health care community is a very important resource as well as a stakeholder group. Its members are highly trusted in the community, fully conversant with technical language and concepts, and undoubtedly a key part of the community's emergency planning and response network. In this group are psychologists and mental health experts who can provide invaluable help and advice concerning issues of stress, post-traumatic care, and the identification of special counseling programmes, among other things.

58. Experiences were shared about the development of new tools and techniques to assist in the risk communication process. For example, consideration was given to how to address concerns of specific stakeholder groups and ways of enhancing trust and credibility. The description of pilot projects which aimed at examining in detail the risk communication process in differing environments provided graphic evidence of the considerable effort and resources that may be required. Some of the development activities that were part of these projects included handbooks with very specific guidance about stakeholder groups, techniques of framing risk language, dealing with hostile audiences, and meeting processes. Other tools include such things as training and development courses for communicators. Sharing of information and lessons learned from specific risk communication projects in OECD and other countries would be helpful. Furthermore, there may be benefits in the development of guidance for the risk communication process. The improved sharing of information and the guidance document could contribute to the continuing evolution of risk communication processes in OECD Member countries as well as non-member countries.

59. The Workshop noted that special problems in risk communication may exist for small and medium-sized enterprises (SMEs) since they can and do cause serious accidents. It was recognized that SMEs are subject to the same legally mandated requirements for disclosure and risk assessment as any other company, and assistance or special attention in risk communication should be linked to assistance in other areas of regulatory compliance and risk management. Experience indicates that larger companies can assist the SMEs through, e.g., mentoring or sponsorship initiatives aimed at improving the risk assessment, risk management and risk communication capabilities of SMEs. The Kanawha Valley experience was described, with an indication that it could provide a model which may be beneficial for communities with small or medium-sized companies. This subject needs continuing attention.

60. The Workshop noted that there are benefits in recognizing that workers are sensitive to both company and public views (they work in the company and live in the community, and thereby face risks in the event of an accident both at work and, along with their family, at home). In risk communication, workers are a valuable resource. They should receive training in communications with the community and should feel free to share information with their neighbours. Some companies are actively preparing workers to be credible communicators concerning risks.

61. Risk communication is a continuing process; it should be continued and modified as appropriate to take into account experience and new information. However, care needs to be taken in using accident case histories to re-evaluate risk communication processes since it is often difficult to reconstruct the feelings of those affected by, and involved with, accidents.

62. During and after an accident event, timely, credible, caring, informed, factual and accurate information must be provided openly and continuously to the public. Admitting responsibility or error is one of the most difficult things to do, but one of the most important; it sets the tone for a dialogue with the affected public. This usually requires the direct participation of a senior executive in the risk communication process.

63. The local news media play a key role in any public or crisis communication process. Their acceptance as members of the risk communication process and their cultivation as objective participants is very important. They may be particularly helpful in assisting in developing strategies, which encompass local circumstances and cultural factors, for dealing with the national and international news media in the event of an accident.

64. In the event of a serious accident, the type of coverage obtained will depend on the scale of the event. The local news media, being based in the surrounding community, will interpret information concerning the risk and the management of that risk quite differently from the national and international news media which may cover a major accident. The national and international media will not likely be aware of the needs of the local community and the efforts that have been made with respect to communicating with them about risk. Thus, interaction with the news media may differ substantially depending on their base.

65. Risk communicators should ensure that the messages of their different expert groups are shared and co-ordinated before they are communicated with the public. Risk communication is very much a team effort, and the team should work and train together just as emergency response teams do.

66. Risk communication during an event demands special techniques and systems that are not all included in communications before and after an event. These special needs should be defined and included in risk communication handbooks and training courses.

Recommendations

67. A mechanism should be developed to facilitate the exchange of information and experience on risk communication activities of industry, governments and other stakeholders. As part of this undertaking, an effort should be made to understand the relationship between improved risk communication and enhanced risk management and reduction.

68. A guidance document should be prepared to assist stakeholders in Member and non-member countries involved in risk communication concerning chemical accidents, taking into account existing guidance materials such as that developed by the European Commission. This should address, *inter alia,* the purposes/objectives, pitfalls, techniques, processes and evaluation of risk communication programmes, including those that may be required during and after an accident event. The guidance document could also address the use of terms employed in risk communication to improve mutual understanding.

69. Additional effort also is needed to better identify the situations for which risk communication is warranted and in what way, recognising that different situations would lead to different approaches.

70. Efforts should be made to improve the education and training of all those involved in the risk communication process. This could involve exploration of opportunities to develop joint or collaborative training activities. Consideration could also be given to developing criteria or qualifications for training

programmes, including the possibility of establishing certifications for those involved in risk communication.

71. Recognizing the risk communication provisions of the UN/ECE Convention on Transboundary Effects of Industrial Accidents, the EU Directive, the APELL Handbook, as well as the OECD Decision-Recommendation and Guiding Principles on this subject, further joint activities should be undertaken to facilitate the ability of Member and non-member countries to ensure efficient and effective risk communication concerning chemical accident prevention, preparedness and response.

DISCUSSION DOCUMENT ON RISK ASSESSMENT

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Summary

Risk assessment in chemical accident preparedness and response has to be viewed in the wider context of technical risk assessment as practised in many industries. The impetus for particular forms of risk assessment have been fashioned by wider cultural factors. The social and economic environment have helped to shape the approach taken. Therefore it is not surprising that there are significant differences in the way in which risk assessment is tackled between nations.

Risk assessment has the following essential components:

- *hazard:* — *an inherent property of a situation*
- *hazard identification:* — *systematic investigation of possible hazards*
- *events identification:* — *determination of the different situations that can occur and lead to harm*
- *events frequency:* — *an estimate of the number of times an event occurs within a specified interval*
- *consequence assessment:* — *an estimation of the damage caused by an event*
- *risk characterization:* — *integrating the above into a combined estimate of risk*
- *determining significance:* — *evaluation of the significance of a risk estimation*

The way in which these components are employed is dependent on the context. This paper initially explores some of the evident differences in approach as they relate to the background from which they come. In Germany there is a traditional reliance on establishing regulations and standards that provide an implicit control of the risks associated with manufacturing and handling hazardous chemicals. A more laissez-faire *approach, in which risks are dealt with by explicit identification and remediation, is typical of the methods employed in Norway, the UK and the Netherlands. However, there are in reality elements of both prescriptive and goal-setting in all cases examined in a review of methods (47) that provided background for this paper.*

A number of generic methods can be employed to mitigate or prevent excessive or unwarranted risk. These include: inherently safe design of processes, separation of source and receptor, improving containment of a hazard, and improving control and management of hazards and risks.

To choose between measures usually requires consideration of their costs and the benefits produced. However, producing a cost/benefit case is often very difficult in the face of uncertainties.

In principle, preparedness for and response to chemical accidents can be planned by examining the results of a risk assessment. In practice, it is usually necessary to develop the assessment made in order to obtain the appropriate information. The way in which emergency response is organized has to be considered, as well as the scale and the time taken for an accident to manifest itself in relation to the ability to respond.

1. Introduction

The purpose of this paper is to examine the use of risk assessment in chemical accident prevention, preparedness and response. The way in which risk assessment has evolved is a starting point. Its origins establish the dynamic for its development. But it is also important to note the technical, legal, cultural and political considerations that have influenced its current state. These have produced significantly differing approaches to the prevention of, and preparedness for, chemical risks.

To do this, the scope of risk assessment as it applies to chemical accident hazards will be explored. Risk assessment is a process with many components. The key terms will be introduced, and a glossary of terms derived from previous publications is attached. The components of risk assessments will be introduced because these are the building blocks of all risk assessments. The way in which components are used reflects the different emphasis associated with particular situations or based on specific rationales.

Nearly all members of the public are aware of the existence of the risks from chemicals. But who are the real "stakeholders" in deciding how chemical risks should be managed? In looking at the development of risk assessment, in the following sections, the various stakeholders are identified. Their participation and responsibilities in the risk assessment process are discussed to a limited extent.

There is no doubt that risk assessment is not a well-defined term. A recent study undertaken for the government of the Netherlands examined the ways in which risk assessment was being practised in various selected countries. This paper draws upon the information collected and analysed in that study. Its purpose is to show examples of the spectrum of approaches and point out some of the different factors that influence their use in practice.

In exploring how risk assessment is undertaken, its use in prevention, preparedness and response is also illustrated. This is the central purpose of the Workshop. Illustrations of how risk assessment is defined in practice (sections 2-4 below) form a basis for developing an understanding of its use in chemical accident prevention, preparedness and response (sections 5 and 6). Emphasis will be placed on developing this latter aspect in the Workshop.

A series of questions are provided in Appendix 1, in order to assist Workshop participants to prepare their thought and information on their own particular risk assessment approach in the context of chemical accident prevention, preparedness and response. Its form is based in part on the first part of the investigation carried out by the government of the Netherlands. Responses provided by participants to these questions can help form the basis of additional information, to be added to this document following the Workshop. This will enable a better understanding of how important instruments for risk assessment are applied, and this will help the document provide added value to Workshop participants.

2. Background and Terminology

(i) Historical Context

Risk assessment is not a new art. It has been practised by the insurance markets for at least two centuries as a commercial activity. But long before industrialization, man was familiar with taking and accepting risk. Hunting and making war are obvious examples.

Technical, commercial, economic and social risk is approached in contemporary society in many differing ways which, to some extent, have been produced as a result of the disciplines and perceptions of the main actors in a particular context. Thus there are many variants of overall approach to risk assessment.

The way in which industry has dealt with risks associated with accidents is as old as industry itself. The codes and standards of construction for steam boilers date back to the early days of the introduction of such equipment. In the context of chemical accident prevention, preparedness and response these codes and standards are the foundations of risk assessment and risk control. Standards bodies, insurance companies and independent inspectorates all became part of a well-established structure which still serves this purpose.

Direct risk of death or injury from chemical hazards is but one aspect of the more general risk to the environment as a whole. Chemical accidents can result in severe environmental damage of which account must be taken. Such risks are assessed utilizing essentially the same methodological elements. But environmental risk in the accepted sense of the term embraces other damaging phenomena and other aspects of risk. For example, there may be significant uncertainty about whether the release of a chemical into the environment is responsible for a given detrimental effect. However, environmental risk can be and is embraced by the principles set out below

The parties (stakeholders) principally affected by risk assessment are people and enterprises most at risk. The entrepreneur and the shop floor worker are usually most directly affected. But their interest is often influenced by other factors. Can the avoidance of risk be afforded? Will risk avoidance cause unemployment? Usually the risks to the general public are significantly smaller than the risks to the employees and enterprises associated with a hazardous installation. Nonetheless, the public often perceive a greater danger, since they are involuntarily at risk.

Furthermore, the stakeholders have increasingly asserted their influence in the management of risk. It is well-recognized that all such stakeholders have a right to express their views and concerns, and for these to be properly considered. It is a characteristic of the contemporary scene that this right has been increasingly recognized by all the parties involved.

To be effective, risk assessment must be part of the decision-making process, whether by management of the industry concerned or by the public authority. The way in which the decisions are made deserves consideration. On the one hand, hazards may be rather varied, but the likelihood of an accident happening is connected through the situation in a work environment (typically workplace accidents). On the other hand, a hazard may be very well-defined and can be accurately analysed using predictive methods (the best example of this is a nuclear power plant). These characteristics suggest that there is a range of risk situations for which there are different decision environments. Chemical accidents cover a significant portion of this spectrum.

(ii) Components of Risk Assessment

The risk assessment process, regardless of the method or techniques used includes the following components:

- hazard: an inherent property of a substance, agent, source of energy or situation having the potential to cause undesirable consequences (e.g., properties that can cause adverse effects or damage to health, the environment or property)

- hazard identification: systematic investigation of the possible hazards associated with an installation, particularly identification of the hazards of the chemical(s) that can cause injury or death to people or damage to property by the release of the chemical or by the release of energy in the event of an accident

- events identification: determination of the different situations that can occur and lead to harm, including estimation of the probable quantity, concentrations, transport, and fate of the hazardous substance(s) or energy released in each specified situation, as determined in part by the environmental conditions at the time of the event

- events frequency: an estimate of the number of times a specified phenomenon (event) occurs within a specified interval

- consequence assessment: a calculation or estimate of the nature and extent of the damage caused by all specified hazardous events, including the influence of environmental factors and the probability of exposure of individuals, populations or ecosystems

- risk characterisation: integrates the previous components into an estimation of the combination of the event frequencies and consequences probabilities of the hazardous events specified (for each event and the sum of all events)

- determining significance: evaluation of the significance of the risk estimation and each of the components of the risk assessment process, including elements of risk perception and cost/benefit considerations

The components of the risk assessment process defined above lead to a definition of risk assessment - a value judgement that combines the results of risk characterisation and the estimate of the significance of the risk.

There is another way of looking at the estimation and evaluative steps of risk assessment. Estimation is the technical aspect of what happens when a hazard is present and how often it manifests itself. Evaluation is the part which predicts the effects on people either as individuals or as groups

(iii) Development of Risk Assessment Methods

Over the last 20 years or so, risk assessment took a new direction with the emergence of civil nuclear power. Since its beginnings, the nuclear power industry has had to tackle the problem of demonstrating to the wider public that the risks associated with its activities are negligible. This last word is crucial to the development of risk assessment, for it implies that such a level of risk is estimable. It also means that a defined level can be set which will satisfy the public of the "safety" of the proposed operation.

The issues confronting the nuclear power industry resulted in the development of quantified risk assessment. A regulatory framework capable of dealing with the technical issues emerged alongside the industry's ability to express the case. The foundations of quantified risk assessment were established. The focus of this development was on quantified estimates of risk in terms of consequences of an event and the chance that an event might occur. This concentrated principally on the “mechanical” design of the plant, although it was realised that human factors associated with the operator played a crucial role.

A significant feature of this approach is the use of “synthetic” methodologies to anticipate complex system behaviour. A principle example of these is **fault tree analysis**, in which combinations of faulty behaviour of individual components (e.g. a valve sticking when it is expected to operate) are looked at in combinations. Such combinations are selected and specified in order to mimic the behaviour of the entire design to evaluate whether any “likely” combination which would “break” the system could occur.

This illustration suggests that risk assessment can become very complicated and involves numerous technical considerations. It means that designers must take account of the totality of the mechanical design and of the control devices and requires structuring by the designers of the equipment used for controlling a process. Indeed, such input is required to build up a credible and reliable way of integrating the use of risk assessment techniques and plant design. The technical fundamentals of risk assessment must be kept in mind in examining how differing approaches can deliver results.

There are currently a number of barriers to the widespread use of risk assessment which should be recognised by policy makers in industry and government. Among the major issues currently evident are:

- lack of capacity of experienced practitioners
- consensus on modelling of frequency of hazardous events and estimation of consequences
- improving the failure rate data bases
- experience in the use of QRA for decision-taking within companies
- communication of the meaning of risk assessments within and to company managements, to regulators, and to the public

At the same time that risk assessment was developing in the process industries, another trend was evolving more generally in all commerce. This involves a systematic establishment and implementation of objectives through management or management systems. The principle example of the use of management systems is for quality assurance. A similar approach can be taken to managing safety. The components of risk assessment (see above) can be used to establish the objectives of a safety management system. In addition, the risk assessment process is an integral part of the safety management system itself. Thus employing suitable safety management systems incorporating components of risk assessment becomes another means of controlling risk.

Modern risk assessment and safety management systems were preceded by many successful decades of controlling risk through policies and instruments that required less systematic, analytical or quantitative risk assessment techniques. Nonetheless, older codes and standards and specific regulations were implicitly based on consideration of each step of the risk assessment process outlined above. Such considerations were often less explicit and possibly less transparent than those using newer techniques. It is often difficult to identify the influences that the different components of the risk assessment process had when examining how such “rules” actually affect the estimated risk. In fact, one of the driving forces behind the continuing development of risk assessment methods is the recognised need to improve the consistency and transparency of the risk assessment process and the results obtained. But the means of making the rules (for example, through the involvement of technical experts) assure a reduction of risk.

Technological traditions and legislative history have played a significant part in shaping different views of how the risk assessment process, implicit or explicit, has evolved. Some nations have given greater attention to assessment procedures and their link to the control of risks. This has to some extent resulted from particular developments that have taken place within a country (e.g., the occurrence of a large accident, the development of an industrial sector for which risk is a main issue).

If the reasons for some of the differences in approach to risk assessment are appreciated at the outset, it will be easier for practitioners and decision-takers to recognise how differing approaches can be viewed in context. There is no “correct” way of dealing with risk. But those responsible for regulating or managing risk based on the use of risk assessment procedures need to continue to learn from each other in order to obtain a convergence of performance, even if this is achieved by differing routes.

3. Background to the Use of Risk Assessment in Selected Countries

3.1 Setting Goals

The issue of risk in industrial activities followed the development of the world-wide chemical sector in the 1960's. The way in which public policy was emerging is illustrated by the UK Health and Safety at Work Act of 1974. It was introduced by its authors as inventory and in essence goal-setting in its approach to policy. This legislation embraced all aspects of health and safety at work. While much attention has been given to workplace conditions, this law specifically included consideration of health and safety beyond the workplace.

The Canvey Island Study (45) was designed to examine control over external hazards to a community surrounding an industrial development. This was the first integrated study of a non- nuclear industrial complex. It aimed to estimate the risk and propose measures for its control, based on “criteria”. It established the starting point for others to follow.

The setting of goals requires examination of the principles on which they are based. Generally reducing risk is not free of charge. Making the balance between reducing risk and increasing cost will depend on rules based on differing principles. Three such broad categories suggested are:

- utility based rules (using classical cost/benefit balances in which each side of the equation is given money values)
- equity based rules where the rights of all are equal and the most vulnerable require the most protection
- technology based rules in which the availability of the means to reduce risk is the predominant consideration

In practice, the rules actually adopted are usually combinations of the above.

The frequency of carrying out risk assessments is influenced by many factors. These include:

- the requirements of the legislative or regulative environment; this is the most powerful influence
- industrial accidents and particularly large scale accidents
- insurance
- worker pressure through trade unions
- process changes
- better knowledge of risk
- commitment of management at all levels

3.2 Risk Management Philosophy

The analytical approach (see glossary) developed to evaluate risk is not recognised universally. In effect, it requires those concerned with the risk to address the behaviour of the source of risk in all aspects of its operation. This approach, in more or less quantitative ways, is often used to support "performance based" approaches to risk management. The more traditional approaches to the management of risk work by relying on implicit control of risk. It is this "prescriptive" method which is based on rigorously applied and maintained standards of design and operation. It is often difficult for proponents of this approach to deal explicitly with an analysis of risk. They argue that, if everything required by agreed standards and regulations appropriate for the risk generating process is done, then the risk is controlled.

The inherent integrity of plant is ensured by maintaining a system of engineering standards that takes account of lessons learned by experience. The integrity of plant which has been in operation for some time is assured through rigorous in-service inspection regimes. Standards of operation are ensured through high standards of general training and motivation of the work force.

Obtaining high standards of performance through the prescriptive approaches to the management of risk are certainly feasible. It can be argued that this type of approach is proven (by long experience).

There are some channels of communication (formal and informal) that allow the stakeholders to participate in setting standards. The setting of standards is usually a technical activity in which an appreciation of the detailed engineering issues is required. Therefore, it is usually professional engineering bodies who represent the views and concerns of the broader public. Because of such mechanisms of representation, it can be argued that this approach can offer results that are (implicitly) equivalent to those obtained by the analytical approaches to risk assessment. Comparisons are, however, very difficult to make, if only because this parallel approach does not claim any "result" in terms of explicit estimates of the frequency of failure.

3.3 The Seveso Directive

The Seveso Directive has been translated into national legislation by EU Member States. A common requirement, as specified in the directive, is the preparation by the responsible party of safety reports.

These reports must contain information that demonstrates to the competent authority that the technical means are in place for the safe operation of the installation at all times. The authority must examine the information provided.

The system set up by authorities to ensure that installations are adequately safe varies from country to country. This is evident from the criteria for safety applied. These are reflected in the content - and volume - of the safety reports.

In some countries the overall control of safety is dealt with by more than one department of government. While one authority is principally concerned with safety in the workplace, another has responsibility for safety with regard to the community outside the installation. This has an important bearing on the approach to risk assessment used.

An authority that is principally responsible for safety and environmental effects outside the installation is normally more inclined to adopt a more comprehensive view of risk and its assessment. An authority that is only responsible for the safe design and operation of plants, and is charged with safeguarding the work force, will adopt a strategy focusing on the most common threats to the work force. Such a focus may not identify the issues of concern to the external environment.

Examples of the regulatory systems adopted in a number of Member States of the EU, including those based on the implementation of the Seveso Directive, have been placed in an order that is based on increasing reliance on analytical approaches to risk assessment and more quantified estimations of risk. The philosophical basis of risk management (more prescriptive to more performance based) is shown for each example of national approaches for evaluating and controlling hazardous installations

More prescriptive:

<u>Germany</u>
Analytical approaches to risk assessment techniques have little place, either to demonstrate safety or to judge the tolerability of the risk of an establishment. More reliance is placed on adherence to engineering standards and operational procedures. Risk assessment to estimate the extent of possible consequences of an accident may be made. However the overriding character of the approach is dependence on “standards”;

<u>France</u>
Although authorities recognise the utility of probability as a concept in the assessment of risk, the regulations are centred on safety distances; these result from maximum effect calculations of major hazard units. More quantitative risk assessment studies can be requested by a local authority, but the basis (criteria) on which the results would be judged is not defined;

<u>United Kingdom</u>
The HSE adopts the position that an establishment is not required to include the results of quantitative risk assessment methods as part of a Safety Case; but to do so may make the safety arguments more convincing; the authority may ask for a quantified risk assessment to be carried out in cases where it is indispensable for arriving at informed judgement of the suitability of an installation. Criteria against which the

risk results (both individual and societal) are judged have been addressed in published discussion documents. Frequently such criteria are referred to as "consultation distances", requiring that careful consideration of activities within such distances is required. The influence of valid factors other than absolute safety norms on which to base decisions is given much attention (see risk assessment components above - determining significance); assessments are based on the “cautious best estimate”.

More performance based:

Netherlands

The regulatory framework adopted by the government means that the judgement of the tolerability of the external risk of an establishment is based exclusively on quantitative risk assessment approaches and on numerical risk criteria.

Note: “Analytical” approaches means that the risks are evaluated utilising the steps set out in section 2 above to estimate the level of risk, either quantitatively or qualitatively. “Prescriptive” means that safety of process equipment is essentially obtained through fixed rules relating to the design, construction and operation of the plant. Risk assessment can be used in the context of the establishment of such rules, but is generally carried out in more deterministic ways (see Glossary)

A further example of an approach to risk assessment derived from the requirements of the Seveso Directive is the methodology used in the Walloon region of Belgium. In this the main aspects of risk assessment are recognised. However, interpretation of the results depends upon a judgement of whether or not a particular sort of accident will happen. There is no frequency aspect of the evaluation of such an accident.

3.5 Other Examples of Interaction between Risk Management Philosophy and the Approach to Risk Assessment

Norway

If Norway were to be entered in the list above, it would fall somewhere between the UK and the Netherlands with regard to the type of approach to risk assessment used. Rather than stipulate risk criteria that set (or give guidance on) limits of acceptance of risk, the authorities require companies to declare their safety policy, which includes specifying the safety goals and objectives that hazardous installations should meet. Technical audits and assessments of the installation design and operating procedures ensure that the goals and objectives are being met.

The development of this type of approach or philosophy to management of risk and safety regulation has been principally driven by the need to ensure safety of the off-shore oil and gas industry. The experience to date has been sufficiently positive that work on on-shore safety management is likely to use a similar approach. The Norwegian approach and experience are different in emphasis from those of the other countries examined. It may be useful to consider this as one of the different examples of approaches to risk assessment and the use of its results.

United States

Both the authorities and industry in the USA have developed philosophies to risk management that are in certain ways distinct from the approaches to risk management in other countries. Nonetheless, there are significant similarities to the approaches used by others, including the Seveso Directive. While the federal government has a very significant role in setting the tone and approach to risk management policy, in many aspects of chemical accident prevention, preparedness and response the role of state and local government and industry is significant, particularly with regard to the implementation of safety management programmes designed to meet the safety goals and objectives established. The new rule on chemical accident prevention (24) may have significant impacts on the process of assigning responsibility and measuring the attainment of performance goals and objectives in the longer term.

As an indicator of the future of risk management, the EPA draft rule (24) can also be considered as an indication of possible future action based on current philosophy. A selection of the section headings in the rule demonstrates some of the links between performance based risk management and the portions of the prevention programmes that might involve the use of various approaches to risk assessment or of its results are set out as follows:

- hazard assessment
- prevention programme - management systems
- prevention programme - process hazard analysis
- prevention programme - process safety information
- prevention programme - standard operating procedures
- prevention programme - maintenance (mechanical integrity)
- prevention programme - pre-start-up review
- prevention programme - management of change
- prevention programme - safety audits
- prevention programme - accident investigation
- emergency response programme
- risk management plan
- record keeping requirements
- audits

In the first section is the requirement to assess the effects of the Worst Case Scenario (WCS). This is defined within the definitions in the preamble of the rule as "the loss of all of the regulated substance from the process in an accidental release that leads to the worst off-site consequences". While the use of quantified risk assessment approaches is not necessary, it seems that this approach is intended to embrace all significant components of major hazard risk assessment and the performance based approach to the management of risk.

The WSC concept has been supplemented by including the concept of the worst WSC and the “most likely” WSC, which allows gradations of these major events.

The State of New Jersey has its own specific regulations on the control of risks from toxic gas releases (The New Jersey Toxic Catastrophe Prevention Act - TCPA - 1988) (36). This “rule” was readopted in June 1993 for a further five years. It was brought about by the coincidence of the Bhopal accident and several incidents that are described as near misses in New Jersey. The philosophical approach to the management of risk espoused by this law requires the use of quantified risk assessment methods.

Initially industry in the United States had some concerns about the use of more quantitative methods for risk assessment. Recently the leading process companies have been using increasingly more analytical and quantitative approaches to risk assessment. For example, the Center for Chemical Process Safety (CCPS) initiated the development of its own quantified risk assessment methodology. The diversity of views on, and the choice of methods for, risk assessment remains large in the United States.

Switzerland

Switzerland has distinctive legislative and administrative arrangements as well as a significant number of chemical processing companies. Its regulations as applied to major hazard installations in the Seveso sense require the operator of installations that are subject to the *Storfallverordenung* - dangerous substances regulations (20, 21, 22, 23) - (on the basis of quantity of classified substances) to submit to its cantonal authority (some cantons have set up special commissions for this purpose) a short report that describes the installation, its inventory of hazardous materials, and the means of preventing major accidents. The effect of the maximum release scenarios is to be evaluated in order to determine whether the consequences of the maximum credible accident could potentially cause serious harm outside the installation. On the basis of a critical review and check of this information, the cantonal authority decides whether it is justified to exclude the possibility of a major accident. If so, the installation is acceptable. If not, a risk assessment is requested from the operator which sets out the consequences and frequency of all serious accidents that might occur. The results of this work are critically reviewed by the authority, who then decides with reference to risk criteria whether the installation may be accepted or that further safety measures are needed. In the latter case the risk assessment is repeated until approval is either given or refused.

Japan

The approach in Japan is based on safety management through invoking the approach which characterises the Japanese industry's approach to quality. Thus there is much emphasis on the bottom- up principle, which is described in this case as “small group activity”. Emphasis is given to information exchange and identifying triggers for hazardous happenings. At all levels of the organisation, in both the line and functional structures, the activities required to support a high level of safety achievement are identified and resourced. There is a significant body of regulation of safety- related matters. However, it is recognised that regulation can reduce the effectiveness of a thoroughly integrated systems approach. The main elements of risk assessment are recognised. However, the main emphasis is put on risk identification, which is described as “risk foreseeing and recognition”. Risk reduction is by this means is achieved through effectively reducing the frequency of hazardous occurrences rather than through measures to reduce consequences.

4. Illustrations of the Use of Risk Assessment

The previous section shows that there are different philosophical approaches to the control and management of the risks to health, the environment and property from chemical accidents. These differences give rise to the wide variety of ways in which risk assessment is being practised. No one would claim to have a definitive method for use in all circumstances. These different ways of approaching risk assessment can only be broadly characterised. The following areas were investigated to provide the background and the substance of the setting in which risk assessment is being carried out, in order to facilitate comparison of the different approaches to risk assessment used in practice:

- definition of the risk control objectives to be achieved

- selection and management (including maintenance) of the risk assessment method(s) being used

- examination of the relationship between risk management objectives and the assessment method(s) chosen and used

- identification of the different uses of the results of risk assessment and verification that the results could be used to achieve stated goals

- costs and benefits of using a particular method for certain purposes

Collecting such information required careful selection of sources. The various stakeholders involved in chemical accident prevention, preparedness and response needed to be heard. Given the rather short time available for the preparation of this discussion document, earlier work to survey representatives of both the authorities and industry in a selected number of OECD Member countries, who could give an authoritative evaluation of the current position and trends for the future, was used.

When analysing the information previously obtained, it was regrouped in order to provide the basis for an examination of the current, and likely future, approaches to risk assessment in the countries mentioned in relation to the implementation of risk control policies.

(i) Legal Context

Table 1 below illustrates how the differing "technical" approaches to risk assessment manifest themselves as features of the legal framework in the countries considered. Differing legal traditions and codes result in differing approaches to formulating laws and regulations. The question of embodying risk in legislation is particularly intriguing, as it can lead to questions concerning some of the fundamental principles of the law. The absolute rights of the individual can be part of the foundations of the law. Generating and accepting risk can be considered as an infringement of such a right. This issue is not elaborated further, but should be remembered in considering how risk is accommodated in the law.

Table 1 lists examples of some legal instruments for chemical accident prevention, preparedness and response, and associated risk assessment methods and risk criteria from selected countries, starting at the top of the table with those legal instruments that are more prescriptive to those at the bottom where the legal instrument is more objective or goal-oriented and more performance based. Goal-setting reflects the modern trend towards liberalised regulation. This leaves the decision of the type and extent of measures to be taken to the "economic operator" on the grounds that he/she is best able to judge the most "effective" combination of measures to be taken. It implies that cost/benefit assessment is applied in deciding an optimum strategy for risk control. There is no absolute scale upon which to list the different approaches used. There is always a mixture of prescription and goal-setting. But the listing is used to illustrate some of the influences of legal instruments and approaches to risk assessment methods selected for use by a country.

The columns in Table 1 provide an indication on the following points with regard to how risk assessment is perceived and applied:

- Is the law prescriptive or goal-setting? In broad terms how do laws, regulations and standards fit into the spectrum of prescriptive -> goal-setting?

- Do the regulations relate to technical standards? Are there many (or few) technical standards (e.g. as produced by standards institutes) that are applicable in the laws and regulations relating to risk control for hazardous chemicals?

- Have specified criteria been defined? Are goals set in the form of criteria expressed as levels of risk experienced by people or property adjacent to the risk generator?

- What is the implementing authority? At what level of government is the expertise present to make decisions on the suitability of potentially risk-generating chemical plant? The implementing authority has to maintain a level of competence in applying the law and this may have implications for the "form" (i.e. prescriptive/goal-setting) of the law.

- Is a specific need for quantified risk assessment recognised? Is risk estimation using the quantified risk assessment approach recognised as part of the mechanism of decision- taking within the legal requirements?

Table 1: Assessment and Legal Influence

Country	Is law prescriptive or goal-setting?	Do regulations relate to technical standards?	Have risk criteria been defined and specified?	Implementing authority	Is the need for quantified risk assessment recognised?
Germany	essentially prescriptive	yes	no	by *Länder*	no
France	contains prescriptive elements	not explicitly	yes; zoning distances	separate regional inspectorate (DRIRE)	no
Switzerland	contains strong elements of both	yes	not in regulations but in guidelines	by cantonal authorities	yes
UK	both, but bias towards goals	yes, in some areas	yes, but only in "guidance"	HSE inspectorate	yes
USA (federal law)	essentially goal-setting	yes, in some areas	specific goals and definitions without	state and local levels, if necessary implementing	no, but it can be used
Norway	goal-setting by industry	no	no	occasional Min of Lab audit	implicitly, yes; risk assessment specified as component
Netherlands	goal-setting	yes, indirectly	yes, but not in law as yet	by central inspectorate	yes

Note: Ordered according to degree of legal instrument's prescriptiveness/performance based goal-setting required

It should be noted that judging the legal instruments on a scale of prescriptiveness to goal-setting generally means taking account of a number of related laws. Labour safety laws can account for a significant part of this. Environmental laws may also have a significant role. Sometimes the most important laws are related to planning (land use). Finally, regulations relating to security can also play a part. The more important legal instruments taken into account in this survey are listed in the selected references (below).

(ii) Objectives and Motives for Using Risk Assessment

In general the purpose of laws relating to major hazard risks is to protect people, and in some cases the environment or property, from the harmful effects of major accidents. In the previous survey, all the representatives of enterprises expressed a general desire to protect the public. In some cases, this was backed up by an indication that this message was publicised to enhance the company's image. The concept of sustainable development was mentioned. This refers to the need of the industry to ensure that public pressure will not prevent its development. The experience of the nuclear industry was in mind. Legal obligations featured heavily in the perception of the "associations", but variably in importance among the individual companies. Many of these motives could be more important for the use and development of risk assessment as a tool for risk communication to other stakeholders and risk management by industry.

Attitudes of authorities and regulators to the use of risk assessment vary. In Sweden a recent survey indicates that most commonly risk assessment is sometimes used and/or has led to actions, but among the population of authorities surveyed there was a bias against the use of risk assessment.

(iii) Influence of Risk Management on Assessment

The management and control of risk can be classified into three groups; each category has different influences on the type of risk assessment method that is used. The three types of risk management and control type can be described as follows:

* setting explicit risk criteria
* setting standards (or regulations) that control risk (implicit)
* requiring management of risk (or the management systems approach)

Each of the above categories relates to the spectrum of approaches used in practice to determine whether a particular law applies and risks require control. The first category infers that more quantitative risk assessment techniques will need to be employed to define the criteria or even level of risk that prompts action aimed at control or reduction. The second does not necessarily require the use of risk assessment, since standards and regulations have traditionally been set through a process that does not include all the components of risk assessment. However, setting standards still involves technical evaluation and therefore it is inevitable that some aspects of the risk assessment process will be employed to arrive at a well-founded standard. The third approach includes aspects of the other two, as both standards and risk criteria may be an integral part of the objectives stated for a safety management system. A management system can define its own objectives as a starting point and use highly analytical and systematic approaches to risk assessment. However, there can be a tendency for the approach to risk assessment to lack uniformity if driven solely by the needs of a management system. Complete reliance on management systems could result in some companies exercising little or no use of quantitative risk assessment.

One example of the "systems" approach is based on the application of ISO 9000, a document produced by the International Organization for Standardization that sets out the requirements for achieving product quality. This type of approach has stimulated an awareness of this management methodology as a means of pursuing aims such as the safe operation of a hazardous installation.

a. Industry

Nearly all industries and authorities recognise the need to introduce some measure of each of the components of risk assessment into their risk control strategy. There is some difference in emphasis between industry and government authorities, and this can lead to differences in approach.

All the major process industries interviewed in the previous survey reported the use of a quantified approach to risk assessment as their ultimate recourse. There is usually a selection process by the company for the "candidate" processes, operations or facilities in a hazardous installation for which risk assessment is required. It is recognised that the skills required to undertake such assessments are limited in capacity. Therefore, there is a need to ensure that only carefully selected, priority situations are dealt with by using the more resource- and information-dependant techniques of quantified risk assessment. Table 2 illustrates some of the types of risk criteria specified by industry, for their own purposes. This illustrates the fact that many companies have adopted a definite and positive approach to the quantification of risk in selected cases

b. Government Authorities

Government authorities and their programmes for chemical accident prevention, preparedness and response deal with the whole spectrum of hazardous industrial activities and installations with respect to their use of risk assessment. The use of risk assessment as a part of the process establishing the goals and objectives for their chemical accident programmes must take account of the need to address a broad range of circumstances. The target levels for acceptable risk are often expressed either as broad bands or values (requiring the use of more quantitative risk assessment methods) or in such a way that the relative merits of attaining a level of risk can be evaluated and understood.

The level of risk "permitted" (where specified) is usually subject to further analysis and interpretation (see the components of risk assessment section on determining significance). The integration of an analysis of the costs and benefits of the possible measures to reduce risk is a common activity in this part of the risk assessment process. A level of risk also relates to the public perceptions and acceptance of that level. The uncertainties associated with various factors in the more quantified assessment and the transparency of the process of quantification are important aspects of this type of approach. The interaction of these factors with the risk assessment process and the risk criteria that flow from it can be illustrated by examining an approach used in the United Kingdom. Three principles are adopted in the control of major hazards. These are identification (establishing the existence of a risk), reduction (reducing the possibility of a risk) and mitigation (reducing the impact of a hazard). In some areas of chemical accident prevention, preparedness and response the UK Health and Safety Executive use a principle, "As Low As Reasonably Practicable" (ALARP). It is usually applied to risks that fall below a defined level of "intolerable" risk. This idea is illustrated in Figure 1. But account is usually taken of the different bases on which comparisons can be made (see above).

Another approach to risk assessment, which can be exemplified by the approach taken by government authorities in Germany and France, involves less use of quantified risk assessment. Their approach to risk assessment takes into account the general principle that the zoning of land can separate a hazardous installation from potential victims of an accident. However, their approach to assessment does not rely heavily on a calculation of risk but on a thorough analysis of the standards of the construction, operation and maintenance of the installation. Various aspects of the standards related to risk are rigorously defined and used in a more deterministic way to evaluate the potential for, and the nature of, accidents that might occur. Some of the assumptions involved in this type of approach relate to the estimation of the reduction of risk obtained by the standards imposed and the effects of the separation distances required. Defining the distance between industrial activity and residential populations involves the assessment of the level of reduced risk and implicit determination of the level of risk that is undesirable.

In France, this type of approach involves the assessment of the different levels of danger brought about by the hazard in question. This assessment is done by evaluating the effect distances of "maximum credible accidents" and using these to define zones for new installations.

Government authorities in the Netherlands use quantified risk assessment methods to define target levels of risk (risk criteria or risk zones). The authorities provide quite detailed guidance and specifications of the way in which the risk of a hazardous installation can determined and compared to the criteria established. This includes guidance on how the quantitative risk assessment should be performed.

Table 2: Summary of Risk Criteria Defined and Used by Selected Chemical Companies

Company and Location	**Individual Risk Targets, expressed as Personal Individual Risk**	**Group Risk Targets**
Company A - UK	Employee 3.5 X 10^{-5} Community 10^{-6}	3-10 fatalities - not more than 10^{-4}/yr.
Company B - US	Community 10^{-5} Industrial 10^{-5} Employees 2.5 X 10^{-5}	Community 10^{-5}/yr. Industrial 10^{-5}/yr. Employees Process Hazard Index PHI > 10000
Company C - Norway	Off-side 10^{-5}	Number Frequency 10 10^{-5}/yr. 100 10^{-6}/yr. (for N > 3)
Company D - France		"Qualitative" matrix
Company E - Switzerland		"Qualitative" matrix
Company F - Canada	Unacceptable $>10^{-5}$ Design $<10^{-6}$	

Note: The companies in France and Switzerland do not use precisely defined numerical criteria for risk levels, but rank the outcomes of risk assessment into implied bands of risk levels.

In the UK, the HSE's approach to risk assessment has evolved around three principles:

- Identification - establishing where major hazards exist; enabled by various regulations relating to notification, control and planning in the use of hazardous substances

- Reduction of risk - as required by the Health and Safety at Work Act

- Mitigation - in land use planning and emergency planning

These controls result in the definition of "consultation distances"; developments falling within this distance of the site of a major hazard have to be referred to the HSE, who undertake a technical assessment of the situation (12).

The above example illustrates the varied ways in which government authorities carry out or ask others to carry out an assessment of risk as well as evaluate and set risk criteria. Some of the reasons for the choice are technical (e.g., certain authorities question the robustness of the current body of quantified risk assessment methods while others feel that more "deterministic" methods, which focus on the estimation of the nature and extent of the hazard, do not adequately handle the element of probability which they believe to be an important factor in the assessment and the use of its results). As has been pointed out, legal and administrative concerns also influence the choice of risk assessment methods.

(v) Costs and Benefits

Costs and benefits analysis is not only a sort of risk assessment method, but the results of such analysis can also be used in certain parts of the components of the risk assessment process. These results can influence risk assessment at both the macro- and the micro-economic level. The macro effects are related to the overall effects on the results of risk assessment used in the context of establishing the goals or objective of policy. Cost/benefit techniques can be used in the assessment process to introduce practical considerations (e.g., resource limitations of either government or the industry). Micro effects can be considered as evolving from an assessment of the risks and the comparative costs of possible risk management options. The approach to the integration of cost/benefit into the risk assessment process varies widely both within and between countries. The different ways of approaching this subject are illustrated in section 5.

CBA is rarely, if ever, utilised as the only technique in making decisions. The cost side of the assessment may be relatively easier to estimate. But evaluating benefits means addressing some difficult issues. The value of human life is a difficult issue for government to tackle, in spite of the precedent set by the insurance industry. Nonetheless, some attempts have been made. As well as the qualitative, ethical factors implicit in suggesting a vale for a human life, there is also the matter of the public's aversion to major accidents. Some account can be taken of these, but a CBA has to be undertaken on the understanding that there may be more important considerations which are not usually expressible in quantitative terms. One approach to resolving this difficulty is to introduce the idea of "reasonable practicability", in which a measure is taken to avert risk provided the costs of introducing it are not grossly disproportionate to the benefit in reduction of risk (i.e. likelihood of loss of human life).

5. Risk Assessment and Prevention

5.1 Setting Objectives

The sections above show that risk assessment is interpreted and used in many different ways. Setting objectives is the starting point of any policy. The means of risk control or risk assessment to be used influence the way of setting objectives and vice versa.

The means of achieving control and reduction (i.e. prevention) of risk have been grouped (above) as follows:

- goal-setting (implying criteria)
- prescribing standards (implying existence of standards)
- management control through performance standards (requiring management plans
- and safety reports and verification)

In practice, these are often used in combination. This makes the use of risk assessment in the context of the setting of precisely defined objectives more difficult. Many of the elements and components of the risk assessment process do not explicitly produce a level of risk. Therefore, in combining the information from each of the components, to define an overall measurable "quantity" for prevention is difficult and often lacks transparency.

Goal-setting provides a rational basis for setting the objectives and identifying the elements of chemical accident prevention programmes, as well as a measure against which to judge success. But the objections to some forms of quantification of risk, and the methods used to estimate it in the context of goal-setting, should be recognised. The emphasis placed on how much quantification is appropriate and how it should be derived is a vital element of the risk assessment as a whole.

The transparency of the risk assessment process, including the sources and types of information needed and methods used, is important for the stakeholders involved. Each stakeholder needs to be involved in the processes of estimation and evaluation. How this is done in practice is certain to depend on the underlying legal framework and the specific laws and regulations that relate to the control of risk.

Chemical accident risks and associated goals or risk criteria, and the assessment methods used to derive them, cannot be considered in isolation. The impact of other related policies (e.g., general labour safety, environmental quality and health objectives) also need to be considered in the context of the risk assessment process. To give some idea of the various areas where formalised risk assessment methods are used and by whom several examples are set out in Table 3. The differences between the selected countries are small. "Permitting" assessments and their use are usually devolved to a local level. This requires that local authorities develop the competence to deal with a relatively specialised and technical issue. With regard to the application of laws relating to risk control, the primary authority (i.e. the authority who takes decisions) is identified. In most cases there is reference to the other authorities who have an "interest" in risk assessment for reasons related to either regulations or guidance. In some cases, it was difficult to decide which party had actual responsibilities to either directly carry out assessments or to review and verify the assessment of industry. In some situations, there is an overlap with regard to risk assessment process (e.g., local planning and the authorities involved in the implementation of the Seveso Directive in the EU). Doubt is also expressed in some quarters about the use of risk assessment in the context of licensing decisions.

5.3 How to Prevent Risk

Risk prevention aims to reduce one or more of the contributors to the risk of chemical accidents associated with an installation. Risk assessment methods are used to evaluate the possible impacts of different technical options to reduce the inherent risk of a process or an activity. Choice of the risk assessment method depends on the circumstances. The common principles of risk reduction are as follows:

(i) Reducing Hazard

Inherently safe design of chemical installations usually reduces the extent ("spread") of the hazard. This can be achieved by:

- reducing quantities in a single containment
- changing conditions of a hazardous chemical (i.e. temperature/pressure)
- using a different chemical

These are usually assessed in semi-quantitative ways, and the risk assessments of alternatives are compared against each other rather than against a fixed risk criteria.

(ii) Separating the Source of Hazard from Possible Targets

The effect of a hazard usually diminishes with distance from the source. Therefore, putting distance between source and possible targets reduces risk. This is achieved by:

- effective zoning of land
- plant layout

This area of prevention typically involves the use of exposure assessment techniques. These methods often rely on dispersion and/or other types of environmental exposure models, as well as considerations of the characteristics of the possible sources and types of the release. Information from the exposure assessment is then combined with information from the assessment of the hazard(s) and considerations of target populations. A possible adjunct to these type of assessments is consideration of the effects of barriers to prevent or reduce the spread of the hazardous chemical.

(iii) Improving Containment

Hazards are contained by a "mechanical" (including instrumentation and control) system. The reliability of the system can be improved by:

- better mechanical design (e.g. reducing vulnerable components)
- system redundancy (e.g. parallel controllers)
- additional protection (e.g. double walls, additional control)
- interaction of process components (e.g. layout of plant)

The assessment of this type of prevention measures involves many of the same type of techniques (e.g., comparison of risk) as the other area, but differs in the technical input required for the assessment.

Table 3: Summary of Use of Risk Assessment

Country	In permitting for plant construction or operation	In land-use planning or zoning	For preparing emergency response plans	Responsibility for application of risk assessment of the chemical	Responsibility for labour safety
Germany	*Länder* yes	No	Yes	*Länder*	Separate agencies
France	submit to *mairie*, *préfet* & DRIRE yes	Maximum Credible Accident (MCA) used to establish zones	Yes	Local & DRIRE	DRIRE with Min of Lab
Switzerland	Canton special authorities yes	No	Yes	Canton	Different co-operating agencies
Norway	Company yes	Yes	Yes	Company	Several agencies
UK	Local authority & Dept. of Env. yes	Yes	Yes	Local authority	HSE main responsibility
USA	Owner & local auth.	Yes for local regs.	Yes	State (where active)	OSHA
Netherlands	Provincial and municipal auth. yes	Yes	Yes	Both local & central	Ministry of Social Welfare

(iv) Improving "Software"

Human error is the starting point for four out of five accidents. Improving the performance of the operator therefore offers scope for reducing risk. This can be done by:

- designing out human intervention
- reducing human error rates (e.g., better ergonomics)
- better "design" of organising human intervention (e.g., clearer responsibilities, better communicated instructions)
- better culture, training motivation

The assessments in this area require several different types of expertise (e.g., psychology). Quantitative techniques can be used, but the combination of factors that need to be included in the assessment are difficult to evaluate and their results are difficult to put into forms that can be readily combined.

5.4 Inclusion of Costs and Benefits Considerations

Implementing risk control measures involves costs to the enterprise undertaking them. Therefore, information on cost and benefit are often included in the risk assessment process aimed at accident prevention measures. The cost case is usually handled in a fairly straightforward way. Control of risks from a process hazard usually involves a choice of the application of a well-defined technical measure. Estimating the initial (capital) and operating costs can be done with precision. Difficulty usually arises in estimating benefits. This includes the ethically and morally difficult question of deciding the "value" of human lives. In addition, there are usually a number of intangible costs that are avoided as a result of opting for a particular strategy. For example, production loss is usually a major factor in the costs of a major hazard incident. But determining the benefits of this cost reduction for a particular scenario is usually very speculative and subject to significant uncertainty.

To carry out a macro-economic assessment, indirect effects (e.g., effects on prices, employment) are estimated. These estimate can be facilitated by the use of economic models.

Some governments (notably those of the UK and US) require the presentation of cost/benefit arguments when laws and regulations are presented to the legislature. Obtaining data that is necessary for the inclusion of these factors in the risk assessment process is a major task. An example of this type of assessment can be found in reference 46.

Industry's ability to carry out these analytical techniques is also limited. The provision of properly authenticated data is difficult because the costing of alternatives is not straightforward. Measures to reduce risk can change plant design or operating conditions. This has effects in other parts of the process which can be beneficial. An example is the reduction of inventories of materials. The provision of total cost/benefit assessments becomes a costly activity itself. Technical solutions to reducing risk are often cost neutral.

Companies sometimes make an estimate of what it has cost to develop risk control methodology. In other cases they develop more general data on the cost of submitting plans and negotiating them with the authorities. Enterprises in Germany say that the costs of risk control are significant. In other countries (e.g. France, Norway, the US) there is transference of economic effects through restrictions on development of land around hazardous installations. Such transfers have been seen as free market effects that have sometimes had to be settled by the industry through compensation.

6. Preparedness and Response

6.1 Risk Assessment as an Input to Preparedness and Response

Much can be derived from a risk assessment in planning to reduce the effect of accidents. Risk assessment usually requires consideration of all aspects of the risk of an installation. This process causes the owner to identify and rank the risks. If he undertakes a quantified risk assessment, details of the risk at vulnerable locations (e.g., residential areas) will be calculated. This is raw material for a preparedness and response plan.

Typically, risk assessment is not prepared with this in mind. Usually the emphasis of a risk assessment differs from that required for emergency planning. There are two main reasons for this:

(i) The scale of accidents considered in a risk assessment may be outside the range of practical emergency planning; it will usually be necessary to decide what level of risk should be planned for.

(ii) Some details of how the hazard will affect people (e.g., what sort of injuries can be expected) will not be estimated.

Emergency plans should be based on special risk assessment processes designed to provide the appropriate information. For example, a typical toxic gas produces its effects on the human body according to the magnitude of the received dose. Doses received are a function of the concentration of the gas in the atmosphere and the duration of the exposure. Furthermore, there is often a significant range of dose from which serious (and sometimes irreversible) injury results. The range of dose over which treatable injury occurs can be produced in a much larger area than the area over which a fatal dose will be present. But even making estimates of the areas over which injuries could occur will be a gross over-simplification for the purpose of planning for the effects of a release.

The survey of the use of risk assessment (as produced for the overall case for a hazardous installation) provided little evidence of the direct use of risk estimation calculations for emergency planning. However, it was frequently stated that the analysis of selected scenarios from an overall risk assessment could be of assistance. The emphasis is usually placed on organisation and logistics. It is still a matter of judgement, by experts in emergency planning and risk assessment, to decide how much risk assessment methodology can and should be used in emergency planning.

Another way of looking at this is to formulate a risk assessment methodology that is designed for the purpose of input to emergency plans. In fact, it is probable that the needs for this purpose are so different from the needs of planning and authorising authorities that a new approach is required. However, it should not be the case that these two methods of risk assessment are inconsistent with one another.

6.2 Organisation of Emergency Planning

Emergency response is usually a local government responsibility. Some governments have central units which examine response to catastrophes. But these generally have no working resources.

They sometimes have expert advisory units in emergency response. The key elements of resources at an operational level that need to be considered in risk assessment are:

- fire brigades
- the police
- the military (for extreme cases)

An example of the sort of approach taken by central government is that of the Ministry of the Interior in the Netherlands. Public safety embraces crisis management and disaster control. The steps taken to address this constitute a “safety chain” which comprises:

- proaction (e.g. banning certain types of industry close to residential areas)
- prevention (as described above)
- preparation; drawing up and testing emergency plans
- mitigation; assisting in emergencies
- recovery; returning to “normal” after an accident

The safety chain forms an integral part of the external safety policy supported by several departments.

Institutions at various geographical levels of interest have examined the provision of medical care capability for the purpose of responding to chemical accidents. The accent suggested by a group in the UK suggests that the authorities providing health care need to participate in a multidisciplinary approach. Currently there are still major gaps in knowledge on the resourcing and treatment of populations exposed to accidents. This is also recognised at an international level.

Organising major chemical accident emergency response depends on the organisation of these functions for their more general duties. Major chemical risks will never be a predominant consideration for the emergency services. The need to tackle such incidents will occur very rarely even where there is a concentration of chemical industries. Therefore, there is often little information that can be used to consider the influence of organisational factors in risk assessment techniques for preparedness.

However, some bodies have a mandate and programme to tackle these questions. An example is the programme of the KGPSP State Fire Service in Poland.

Consideration of the skills that local emergency services have to deal with all aspects of chemical accident risks in the risk assessment process is also quite complicated and difficult to handle in a quantitative way. Measuring the capability to put the right expertise at the right point in the response and risk communication chain is vital, as is assessment of the risks to emergency services themselves. Ensuring that there is appropriate information and that the assessment team has good input from emergency responders, including medical staff, is an important factor in simplifying the assessment process.

An important factor for emergency response is the time taken to mobilise response to an accident. Response such as moving people away from a hazard must be looked at in the context of the time over which the hazard is present. Some analysis of data from responses to previous accidents suggests that there may be only marginal advantages to adopting an evacuation strategy in the light of actual experience.

In general, this assessment involves the industry manufacturing or handling the chemicals. Typically the best expertise for assessing the different ways to deal with chemical accidents is with the enterprise producing or storing the chemical. They have knowledge of the equipment capable of handling accidents with chemicals, as well as information from assessments of the possible damage to plant and injury to personnel.

Sometimes the actions that would be obvious in most circumstances can make matters worse in a chemical accident. The use of water to combat fire (or apparent fire) is one example of this. Water reacts violently with some chemicals to produce toxic products. Some chemicals will impair or completely stop internal combustion engines. Such problems need to be identified by the risk assessment, so that they can be avoided in responding to releases of hazardous chemicals.

These illustrations emphasise the need for risk assessment in the context of planning response, but specific information on risk assessment methods designed with this purpose in mind is lacking.

All of the factors mentioned above suggest that planning of the infrastructure and logistics for emergencies is of utmost importance. Of particular importance is the organisation of communication and decision-taking within a chemicals site and by services off-site. Sometimes this is also dictated by questions of jurisdiction. In the case of the emergency services, two or more areas or regions may be involved and, less usually, two or more countries. For this purpose international bodies (e.g. the OECD, WHO) provide a point of communication. However, the resources available to the emergency services are usually tightly controlled. Reacting to major chemical accidents has to be prioritised. The role and competence of the various levels of government are a determinant of the extent to which such accidents can be planned for. Such problems obviously need to be negotiated as input to emergency plans. Obviously risk assessment provides a basis for these decisions.

6.3 Improving the Effectiveness of Assessments

Chemical accidents are very rare. However, when they happen there is an opportunity to measure the effectiveness of risk assessment. Effectiveness can also be examined by observations made during training and exercises of emergency response plans. There are some examples of this, particularly in the energy sector (e.g., offshore oil and gas) and the nuclear industry. For chemical hazards, these exercises are more frequently being carried out, but feedback to assessment process remains slow.

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GLOSSARY OF TERMS

Important terms not defined in the text, but used therein or commonly with reference to risk assessment are:

Acceptability/Tolerability of Risk: A willingness to live with a risk, in order to secure certain benefits.

Accident: Any unplanned, sudden event which causes or is liable to cause injury to people or damage to buildings, plant, material or the environment.

Analytical Approach: Risk assessment approach utilising precise logical or mathematical formulation of a situation providing an understanding of the underlying processes by breaking down into simpler elements.

(Safety) Audit: A methodical in-depth examination of all or part of a total operating system with relevance to safety.

Consequence: Result of a specific event.

Deterministic: Using a formulation of a situation to arrive at a precise (determined) statement of the outcome.

Emergency Preparedness Plan (or) Emergency Plan: A formal written plan which, on the basis of identified potential accidents together with their consequences, describes how such accidents and their consequences should be handled either on-site or off-site.

Employee: A person who is under a contract of employment with an enterprise, including management.

Enterprise: A company or corporation (including transnational corporations) which has operations involving the production, processing, handling, storage, use or disposal of hazardous substances.

Ergonomics: A discipline concerned with designing plant, equipment, operation and work environments so that they match human capabilities.

Event: The realisation of a hazard.

Event Tree Analysis: One of several methods of hazard analysis involving inductive determination of pathways of disturbances having led to a hazardous situation.

Fault Tree Analysis: One of several methods of hazard analysis, involving deductive description of events leading from failures of components to a hazardous situation.

Goal-setting: Setting a well-defined target (either quantitatively or qualitatively expressed) to be achieved.

Hazard: An inherent property of a substance, agent, source of energy or situation having the potential of causing undesirable consequences.

Hazard Analysis: Identification of individual hazards of a system, determination of the mechanisms by which they could give rise to undesired events, and evaluation of the consequences of these events.

Hazard and Operability Study (HAZOP): One of several methods of hazard analysis carried out by application of guide words to engineering and instrument drawings to identify all deviations from design intent with undesirable effects for safety or operability, with the aim of identifying potential hazards.

Hazardous Installation: A fixed industrial plant/site at which hazardous substances are produced, processed, handled, stored, used or disposed of in such a form and quantity that there is a risk of a major accident involving hazardous substance(s) which could cause serious harm to human health or damage to the environment, including property.

Hazardous Substance: An element, compound, mixture or preparation which, by virtue of its chemical, physical or (eco)toxicological properties, constitutes a hazard.

Incidents: Accidents and/or near-misses.

Land-use Planning: Consists of various procedures to achieve both general zoning/physical planning and case-by-case decision-making concerning the siting of an installation or of other developments.

Major Accident: Any unplanned, sudden event which causes or is liable to cause serious injury to people or damage to buildings, plant, material or the environment.

Management: Employees at, or owners of, a hazardous installation who have the responsibility and authority to take decisions concerning the operation of an installation, including decisions relevant to safety and, where appropriate, employees at a corporate level in the enterprise having such authority.

Near-miss: Any unplanned, sudden event which, but for the mitigation effects of safety systems or procedures, could have caused serious injury to people or serious damage to buildings, plant, material or the environment or could have involved a loss of containment possibly giving rise to significant adverse effects.

Notification: A requirement to provide specified information related to a hazardous installation in an appropriate manner to competent authorities.

Performance Based: Assessment or action on a view of how an entity or system behaves.

Prescriptive: Rules, regulations or standards which define precisely actions to be taken.

Probability: Extent to which a defined event is likely to occur; measured as the number of outcomes of the defined event divided by the total number of outcomes.

Public Authorities: Government bodies at national, regional, local and international level with the authority to issue licenses, regulations, standards or other instructions having the force of law.

Reasonably Practicable: All which is possible subject to the qualification that the costs of the measures involved are not grossly disproportionate to the value of the benefits obtained from these measures.

Residual Risk: The risk still remaining after the implementation of risk management practices.

Risk: The combination of a consequence and the frequency of its occurrence.

Risk Assessment: The value judgement of the significance of the risk, identified by a risk analysis taking into account any relevant criteria.

Risk Management: Actions taken to achieve or improve the safety of an installation and its operation.

Safety: A situation without unacceptable risks. For purposes of this text, safety embraces health, safety and environmental protection, including protection of property.

Safety Report: The written presentation of the technical, management and operational information concerning the hazards of a hazardous installation and their control in support of a justification for the safety of the installation.

Storage Facilities: Warehouses, tank farms and other facilities where hazardous substances are held.

Appendix 1

Questions on Risk Assessment and its Use in Prevention, Preparedness and Response

1. Defining Risk Assessment in the Context of Prevention, Preparedness and Response:

(a) Does risk assessment contain the following components and if so to what degree?

* hazard identification
* specifying hazardous events (or scenarios)
* estimating hazardous event (or scenario) frequency
* estimating consequences of hazardous events
* estimating risk from combining hazardous event consequences and/or frequencies
* evaluating the steps in making the risk estimation and the risk estimate as a whole to produce a risk assessment
* assessing the meaning of the risk assessment as a basis for decision-taking

(b) What other important components are involved in the assessment of risk?

* standards and regulations relating to the design and operation of chemical processes and handling of chemicals
* management procedures and systems
* others (please define)

(c) How are the objectives of risk assessment and control set? In what terms are these objectives (goals) set?

* goals set in terms of risk levels
    - quantitative
    - qualitative
* technical standards met
* standards of management as defined by a defined system of management
* other forms of objective

2. The Influence of Laws and their Implementation

(a) What are the main legal instruments which affect the conduct and use of risk assessment in the context of chemical accident prevention, preparedness and response?

* planning controls/ zoning controls
* labour safety law
* environmental laws
* laws relating to specific activities (e.g. production of chemicals, transportation of hazardous goods)

* disclosure of information laws
* international laws or conventions (e.g. EU directives)

(b) What level of government is involved in the risk assessment of chemical accident hazards?

* town/community government
* area/provincial/metropolitan area control
* national labour or environmental or other agency or department

(c) To what extent are economic considerations taken into account in the risk assessment process? Is this because of a legal requirement? How are these considerations determined and applied in practice?

* Is cost/benefit analysis applied at any level? If so how is this verified?
* Are the costs and benefits of regulations as a whole assessed?
* Does the ALARP principle or similar (e.g. Best Available Technology (BAT) in environmental regulation) apply?

3. Risk Assessment and Accident Prevention

(a) Taking account of the components of the risk assessment expressed above, what are the main approaches to risk assessment used in the context of prevention by means of the following prevention measures?

* separation distances between source and receptor
* specific source limiting measures (inherently safer plant)
* more reliable containment and control through better engineered and constructed plant and components
* better operational management performance (i.e. operating given plant in a safer fashion)
* better overall definition of management objectives and performance with regard to risk control
* understanding of the aspects of the risk that can be mitigated
* other means of risk prevention

(b) How is risk prevention measured or estimated?

* in terms of overall performance of the nation and/or by industry sector
* in terms of a specific hazard (e.g. the siting of a new plant in relation to its neighbours)

(c) How does the assessment of risk for purpose of accident prevention in the manufacture and handling of hazardous chemicals take into account other risks and their regulation?

4. Risk Assessment for Preparedness and Response

(a) How can risk assessment methods be utilised to be prepared for major accidents and in response to such accidents?

* defining scenarios for which preparation and response can reasonably be planned
* giving information on distances at which various levels of effects (e.g. serious injuries, apparent but not real danger)
* providing information to form the basis of mitigating measures (e.g. closing windows and doors versus evacuation)
* evaluation of scenarios to provide basis for emergency planners

(b) How can risk assessments assist the organisation of emergency plans?

* defining typical accident scenarios that will enable on-site and off-site effects to be estimated
* estimating impact of accident scenarios on response organisation
* establishing reliable sources of information in the needed time frame
* providing input for the different response resources taking account of their strengths and limitations in respect of interpreting the information

DISCUSSION DOCUMENTS ON RISK COMMUNICATION

Following are two Discussion Documents concerning risk communication in the context of chemical accident prevention, preparedness and response. They were designed to facilitate discussion of issues related to the development and implementation of policies and programmes for risk communication involving public authorities, industry (including management and labour), emergency responders, the potentially affected public, community organisations, the media and other stakeholders.

The first document, "Considerations and Principles for Risk Communication for Industrial Accidents," set the scene for Workshop discussions by describing the challenges in designing and implementing risk communication programmes. It also reviews major approaches that have been undertaken, identifies guides for designing such programmes, and addresses means for evaluating risk communication.

The second document, "Communication with the Public: Risk Management and Worst Case Scenarios: The Kanawha Valley Experience," provides a first-hand account of developing and implementing a programme for risk communication in a community in the eastern United States where eight major chemical companies have facilities. In addition to describing the issues that had to be addressed, and the practical solutions which were found, this document lists a number of lessons which were learned from the risk communication process.

CONSIDERATIONS AND PRINCIPLES FOR RISK COMMUNICATION FOR INDUSTRIAL ACCIDENTS

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Introduction

In 1988, the OECD adopted Council Act C(88)85, aimed at "the provision of information to the public and public participation in decision-making processes related to the prevention of, and response to, accidents involving hazardous substances" (OECD 1990, 10). This Act recognized the rights of potentially affected publics to information regarding hazardous installations and accidents that might occur at such installations. A 1990 Workshop in Stockholm addressed the provision of information to the public and a subsequent meeting in Boston in the same year dealt with emergency preparedness and response. Meanwhile, extensive developments have occurred in risk communication in individual European countries and in the United States over the past decade (Baram 1993; Gow and Otway 1990; Kasperson and Stallen 1991; Pidgeon, et al. 1992).

This background paper builds upon these earlier discussions as well as the growing, and now quite substantial, body of research on risk communication. There is, as well, now substantial accumulated experience with industrial accidents and even a journal, *Environmental and Industrial Crisis Management*, that focuses on research on this topic. In this assessment we begin with a discussion of the challenges facing those responsible for designing and implementing risk communication programs. We then review the major approaches that have evolved to accomplish this task, and consider in some detail one integrative approach - the "social amplification of risk" -to guide studies of risk and risk communication. Tapping research on risk perception and risk communication, we identify potential guides for designing communication programs and assess the particular issues posed by emergency situations. Finally, the paper addresses how success or failure in risk communication may be evaluated. The intent throughout, it is important to emphasize, is to be suggestive rather than to be prescriptive.

The Challenges of Risk Communication

Just as many types of risk communication are continuously at work in society (see the discussion of the "social amplification of risk" below), so too are diverse challenges that risk communication must overcome before, during, and after accidents - to be successful. Prominent among these are the distributed decision setting, the nature of public perceptions and concerns, and the need for flexibility and resilience.

The setting. **Distributed decision systems**. Emergency response to industrial accidents necessarily involves integrating information and action across a wide variety of expertise, public and private sectors, differing levels and agencies of government, responsible officials, and numerous publics. Major accidents call for what Lagadec (1987, 29) terms "organizational defense in depth". It is estimated that the response to the Three Mile Island accident involved up to 1,000 different decision-makers, not counting the publics. Assuring the timely flow of information and co-ordinating efforts in such a widely dispersed decision structure can be a Herculean problem that harbors countless opportunities for failure. Another key problem is that emergencies frequently necessitate that organizations assume roles and responsibilities that are unfamiliar and that they interact with other organizations with which they do not normally interact. Organizational co-ordination and performance are central factors in the success or failure of emergency response during accidents.

Distributed decision structures raise a series of intrinsic problems that are not easily overcome. The agencies involved have competing missions and priorities and, not infrequently, rivalries. Crises are not only substantive problems requiring solutions but opportunities for settling old scores, enlarging funding sources, and changing organizational mandates and programs. Problems tend to be defined in different ways and information often carries conflicting meaning.

It is not uncommon that emergency planners and risk communicators seek answers to institutional fragmentation in command-and-control structures, often modelled on the military (Quarantelli 1988). The command-and-control structures that have evolved do have a number of attributes responsive to emergency situations. Ordinarily, such structures provide dear delineation and enumeration of tasks. A strong vertical organization with well-developed channels of communication assures the rapid dissemination of information. To a varying degree, the inclusion of back-up systems permits accommodation should particular links in the system fail. Overall, such structures attempt to deal with the authority dispersion problem by imposing detailed articulation of roles and tasks and by invoking predefined categories of accidents and emergency response. At their best, such structures are capable of rapid diagnosis, complex task accomplishment, and timely response.

But they also are prone to failures. The intelligence system depends heavily upon the accuracy of assumptions and diagnosis at the apex of the system, for the upward flow of communication is characteristically weak. Even when signals come in from outlying areas, the command function often has difficulty interpreting or assigning priority to them. Command-and-control structures also tend to develop *rigor mortis* as guidelines become regulations, assumptions reality, and broad categories substitute for rich variance. As a consequence, unexpected situations that do not fit preconceived structures can easily result in delayed or maladaptive response. Meanwhile, participants all too often know only their specific roles and have little sense of the response system as a whole.

So, risk communicators confront a central problem - how to ensure timely and effective response from multiple and dispersed decision-makers on the one hand and how to maximize local knowledge and adaptiveness by publics on the other. A central problem is how to make accident response processes resilient to surprise and failure.

Public perceptions and behavior. The success of risk-communication programs also depends upon their sensitivity to the perceptions of risk and the behavior of various publics before, during, and after an accident. Much knowledge exists about how various publics view different types of risk, about the elements of a warning system that will facilitate effective public responses, and about likely public behaviors under high stress.

Yet stereotypes and misconceptions abound. Many emergency planners fret about the panic they regard as almost certain to erupt during an emergency despite the rarity of such instances. Others seek plans to overcome the likelihood that emergency workers will fail to perform their specified duties, although cases of emergency-role abandonment are almost totally absent in disaster experience. Still others worry about overwhelming the public with information, although experience suggests that publics seek and can process an extraordinary amount of information during serious emergencies. Even human nature comes into question, with managers" fears over antisocial behavior at odds with the observed tendency for widespread altruistic actions by publics. Major improvements in risk communication and emergency planning are possible by narrowing the gaps between what is known, what is practiced, and what is assumed by the professionals.

Beyond that, we do, of course, need to know more. The social amplification of risk (see below) that trails in the wake of accidents is a major driving force in defining the requirements for emergency planning. How prepared should society be for rare but catastrophic industrial accidents? What contribution can risk communication make to assure safety for any given facility? How much of society's scarce resources should be allocated to communication programs? How much variation exists among various publics in their reactions to different accident events?

Flexible and resilient risk communication. Improved emergency preparedness places heavy burdens on effective communication of risk information prior to, during, and after accidents. The communication needs exist at multiple levels - the risk assessor must inform the industrial manager and the emergency planner, representatives of the mass media must be knowledgeable, information must flow effectively throughout the overall emergency organisation, and publics need some understanding of potential accidents as well as available means for protecting themselves. The accumulated experience with industrial emergencies increasingly points to an environment rich in timely and accurate information as perhaps the most precious of all emergency resources. At the same time, the Bhopal, Mexico City, Chernobyl, Three Mile Island, and Rhine spill accidents suggest how vulnerable risk-communication systems can be to communication breakdowns and distortions.

We have gained much useful knowledge of communication and educational systems for preparing communities and local publics for accidents at industrial facilities. Yet many risk communicators are still reluctant to trot out all of the bad things that could potentially happen at plants that want to be seen as "good neighbors”. Local government officials are sometimes loath to assume new burdens that they are ill-equipped and poorly supported to carry out. And always lurking is the ever-present fear that frank talk about potential accidents may spark overreaction by ill-informed publics and media representatives and prompt mischief by miscreants who are potential opponents of the plants. Overcoming the reluctance of those who possess knowledge of the risk to share it openly with those who are at risk is an essential task of risk communication.

Complicating the task at hand are the difficult questions regarding what should be communicated. The public-information brochures that have been prepared for nuclear and chemical emergencies tend to concentrate more on *what* publics need to do than why they need to do it. These brochures are directive and prescriptive but often not pedagogic. Improved approaches will need to go well beyond prescriptive action guides to broad programs aimed at enhancing local knowledge about risks and at enlarging the basic capabilities of various publics to protect themselves from industrial accidents. Such programs will involve not only brochures and pamphlets but also training, risk education, study circles, and participation in emergency-response simulations and exercises.

Communication during crises requires special handling, for time is characteristically short, stress high, and confusion abundant. Experience speaks to the need for multiple channels of communication, the use of credible sources of information, the importance of care in designing messages, the frequency of message transmission, the need for message validation, consistency among message sources, prior training of mass-media representatives, redundancy in communication mechanisms, and effective rumor control. It is also apparent that the characteristics of the risk event (e.g., rapid onset, the persistence of the consequences) as well as the levels of public concerns are important considerations in the design of effective risk-communication programs.

Given our still limited understanding of how to design and implement effective risk-communication programs, false steps and approaches are nearly certain. A well-designed risk-communication program should therefore assume that surprises and failures will occur, and plan accordingly. Programs should, thus, anticipate conflict among information sources; unforeseen events; potential blockages in information channels; inadequate identification of interested groups and citizens; unidentified value structures and community agenda; higher levels of distrust than assumed; and substantial divergence in the risk judgments of experts and lay persons. The objective of anticipating failure should be to make the communication process resilient, so that accurate information gets through, local knowledge develops, interaction occurs, and credibility grows in the face of adversity and the unexpected.

Approaches to Risk Communication

Different approaches to risk communication have evolved over the past decade. What follows are several major types and how they reflect communication objectives and underlying assumptions. They are essentially implicit notions of risk communication that are sometimes complementary, sometimes inconsistent, sometimes in conflict.

The information systems approach. One common approach to risk communication arises from the field of information systems, which focuses on such concepts as sender, receiver, messages, information channels, channel density, target audiences, and information overloads. These concepts have enjoyed wide use in communication engineering, which structures the communications process as (1) the communication source, (2) the message, (3) the communication channels, and (4) the receivers. The *source* refers to sender of information (e.g., credibility). The *message* involves the specific package of information used to accomplish a particular purpose; it may be factual or emotional in appeal and may use or avoid symbols. The goal may be, alternatively, to incite to action, warn, inform, change behavior, or reassure. Lee (1986) notes that designing messages needs to address such factors as emotional versus logical presentation; appeals to fear; message style; implicit versus explicit conclusions; placing explicit conclusions first versus last; and where the message is pitched.

Communication *channels* include not only, prominently, the mass media, but other interpersonal and intergroup networks as well. The *receivers* in this approach are those for whom the messages are designed - the risk bearer, the risk manager, the general public, or publics with special needs. The design of the risk communication system focuses on four components - source, message, channel, and receiver. The assumption is that the key to success is the timely and efficient flow of messages from source to receiver, through diverse channels, with as little loss of information as possible.

The marketing approach. The marketing approach to risk communication consists of a diverse set of methods and strategies that have evolved in advertising and marketing products to consumers. In this view, risk communication is not essentially different from the selling of soap.

Research on consumer information recognizes the various limitations that confront prospective consumers of information. The difficulty of consumer choice, for example, relates to the number of alternatives that exist and the extent to which information formats actually facilitate comparisons. The amount of time available for processing information suggests that some media are preferable to others. The information format chosen can either facilitate or impede the amount and type of information processing that is possible.

The concept of market segmentation recognizes the basic fact of individual differences in interest and need. The goal of segmentation is to produce the most efficient groupings of people (i.e., disaggregation of the market) so that marketing may target its message to particular consumer groups.

Much of this risk communication approach derives from the "do's and don't's" emerging from the practical experience of advertising and marketing, as suggested in Lesly's guides for effective communication (Lesly 1982).

The psychometric approach. If information systems highlight message flows and marketing approaches emphasize consumer behavior, then psychometric studies center on the "receiver" - the individual who is coping with alternative decision situations and making judgments based on perceptions and values. The psychometric paradigm uses analytical techniques to produce representations, or "cognitive maps", of risk attitudes and perceptions (Slovic, Fischhoff, and Lichtenstein 1986). In this approach people are asked to make judgments about the riskiness of different risks and the desirable level of regulation for each. The judgments are then related to such issues as (1) attributes of the risks (e.g., voluntariness, dread, knowledge), (2) benefits accompanying the risk, (3) number of deaths caused by the hazard in a disastrous year, and (4) the seriousness of each death from a particular risk relative to death from other causes (Slovic, Fischhoff, and Lichtenstein 1986).

This work has led to important conclusions directly relevant to risk-communication efforts, namely that

- to cope with decision and information overloads, people simplify;
- once people's minds are made up, it is difficult to change them;
- people remember what they see. For most people, the primary sources of information about risk are what they see or hear in the news media and what they observe in everyday life;
- people cannot readily detect omissions in the evidence they receive. As a result, their risk perceptions can be easily manipulated;
- people disagree more about what risk is than about how large it is. Ordinary people and risk managers typically use the term "risk" very differently;
- people have difficulty detecting inconsistencies in conflicting risk information. As a result, risk communication needs to provide people with alternative perspectives;
- people have difficulty evaluating expertise (i.e., who is an "expert” and who is not)

The cultural approach. This approach to risk communication begins with the premise that different cultures exist in society, each with its own characteristic view of the world or cultural bias, including viewpoints on risk and danger (Douglas and Wildavsky 1982). People structure their world views in ways that are consistent with their shared, daily social experience. It has been argued (Rayner 1984; Rayner and Cantor 1987) that there may be as few as four basic ways of structuring a world view, according to what has been termed the "grid" and "group" variables of organizational life. Grid refers to the degree of constraint that exists on individual interaction; group refers to the range of social interaction. These dimensions can be used to generate different prototypical visions of social life. Seen this way, risk is a way of classifying a whole series of complex interactions and relationships between people, as well as between people and nature (Rayner 1984). This perspective on risk has generated a number of propositions relevant to risk communication:

- Culture is the framework by which people recognize risks. The community is the context for the individual's view of the world and the scale of values by which different risk consequences are reckoned grave or trivial (Douglas 1985);
- A broad definition of risk is needed that encompasses concerns about equity and values as well as concerns about the probability and magnitude of adverse consequences;

- Technology options must be debated on the explicit basis of trust and equity rather than simply rival estimates of quantitative risk;

- Different corporate and governmental cultures engaged in controversies over risk have great difficulty in understanding the fears and objections of others.

The public-participation approach. The 1980s and 1990s have witnessed increased expectations by citizens of their right to know and to participate in public decisions that affect their lives. In Europe, the Seveso accident had far-reaching implications for the European Community in the form of the Seveso Directive, which imposed obligations for both the assessment of risk and its communication to responsible authorities and the public. OECD Council Act C(88)85 establishes that potentially affected publics have a right to, as well as a need for, information regarding hazardous installations. In the United States, the Occupational Safety and Health Administration's hazard communication rule set forth new expectations and responsibilities for informing those at risk. The 1987 U.S. Superfund amendments not only expanded hazard-communication responsibilities but substantially increased local participation in hazard assessment as well.

Experience with public participation over several decades has afforded a variety of insights into both the nature of the obstacles and realistic expectations of what is possible. Research on public participation suggests guides for formulating risk-communication programs:

- Conflicts emerging in public participation often center on means/ends differences in expectation. Publics often see programs as an invitation to share power, to participate in defining goals. Managers, by contrast, often see it as having primarily an instrumental function, a means to realize established health and safety objectives;

- A lack of early and continuing involvement of the public is a characteristic source of failure;

- The believability of risk information is clearly related to institutional credibility and trust;

- Effective public participation depends substantially on the development of resources and the means to act on and assess increased knowledge;

- Members of the public differ from country to country and from culture to culture, suggesting the need for differing communication strategies;

- Although a large array of participation programs exists, current knowledge, especially about risk communication, does not allow for successful prediction as to which forms of participation are likely to be most effective under different conditions and in different communities or cultural settings.

An Integrative Approach: the Social Amplification of Risk

The differing approaches to risk and risk communication outlined above suggest the need for an integrative framework. The social-amplification-of-risk framework is based on the thesis that accidents and other risk events interact with psychological, social, institutional, and cultural processes in ways that can heighten or attenuate perceptions of risk and shape risk behavior (Figure 1). Public responses, in turn, generate secondary social or economic consequences. These consequences extend far beyond direct harms to human health or the environment to include significant indirect impacts such as liability, insurance costs, loss of confidence in institutions, stigmatization, or alienation from community affairs (Kasperson, et al. 1988).

Such secondary effects often (in the case of risk amplification) trigger demands for additional institutional responses and protective actions, or, conversely (in the case of risk attenuation), place impediments in the path of needed protective actions. In our usage, “amplification" includes both intensifying and attenuating signals about risk. Thus, alleged "overreactions" of people and organizations receive the same attention in this framework as alleged "downplaying."

Some terms used in this concept need further explanation. Risk, in this view, is in part an objective threat of harm to people and in part a product of culture and social experience. Hence, risk events are "real." They involve transformations of the physical environment or human health as a result of continuous or sudden (accidental) releases of energy, matter, or information or involve perturbations in social and value structures. These events remain limited in the social context unless they are observed by human beings and communicated to others (Luhmann 1986, 63). The consequences of this communication may lead to other physical transformations, such as changes in technologies. The public experience of risk is, therefore, both an experience of physical harm and the result of cultural and social processes by which individuals or groups interpret risks. These interpretations provide rules of how to select, order, and explain signals from the physical world. Additionally, each cultural or social group selects certain risks to worry about even as it dismisses other risks as not meriting immediate concern.

The amplification process starts with either a physical event (such as an accident) or a report on environmental or technological risk. Some groups and individuals also, of course, search for risk events related to their agenda of concern. In both cases, individuals or groups select specific characteristics of these events and interpret them according to their perceptions and values. They also communicate these interpretations to other individuals and groups and receive interpretations in return. Social groups and individuals process the information, locate it in their agenda of concerns, and may feel compelled to respond. Some may change their previously held beliefs, gain additional knowledge and insights, and be motivated to take action. Others may use the opportunity to compose new interpretations that they send to the original sources or other interested parties. Still others find the added information as confirming long-held views of the world and its order.

The individuals or groups who collect information about risks communicate with others and thus act as *amplification stations.* Amplification stations can be individuals, groups, or institutions. Amplification may differ among individuals in their roles as private citizens and in their roles as employees or members of organizations.

Membership in social groups affects what risk information the individual regards as significant. Information that is inconsistent with previous beliefs or that contradicts the person's values is often ignored or attenuated. It is intensified if the opposite is true. Individuals act as members of cultural groups and organizations, which also determine how people process and respond to accidents. In this framework, we term these as *social stations of amplification.* Thus, publics perceive risk information and messages and construct the risk "problem" according to their cultural biases and the views of their organization or group (Johnson and Covello 1987).

The information flow depicting the accident or risk event and the actions of social amplification stations generate secondary effects that extend beyond the people directly affected by the accident. Secondary impacts include such effects as:

- enduring mental perceptions, images, and attitudes (e.g., antitechnology attitudes, alienation from physical environment, social apathy, or distrust of risk-management institutions);

- impacts on the local or regional economy (e.g., reduced business sales, declines in residential property values, and drops in tourism);

- political and social pressure (e.g., political demands, changes in political climate and culture);

- social disorder (e.g., protesting, rioting, sabotage, terrorism);

- changes in risk monitoring and regulation;

- increased liability and insurance costs;

- repercussions on other technologies (e.g., lower levels of public acceptance) and on social institutions (e.g., erosion of public trust).

Secondary impacts are, in turn, watched by social groups and individuals so that additional stages of amplification may occur to produce higher-order impacts. The impacts thereby may spread, or "ripple", to other parties, distant locations, or future generations. Each order of impact will not only disseminate impacts but may also trigger (in risk amplification) or hinder (in risk attenuation) positive forces for risk reduction. The concept of social amplification of risk is hence dynamic, taking into account the continuing learning by society in the experience with risk.

The analogy of dropping a stone into a pond (see Figure 1) illustrates the spread of these higher-order impacts associated with the social amplification of risk. The ripples spread outward, first encompassing the directly affected victims or the first group to be notified, then touching the next higher institutional level (a company or an agency), and, in more extreme cases, reaching other parts of the industry. This rippling of impacts is an important element of risk amplification since it suggests that the processes can extend (in risk amplification) or constrain (in risk attenuation) the temporal and geographical scale of impacts associated with an accident.

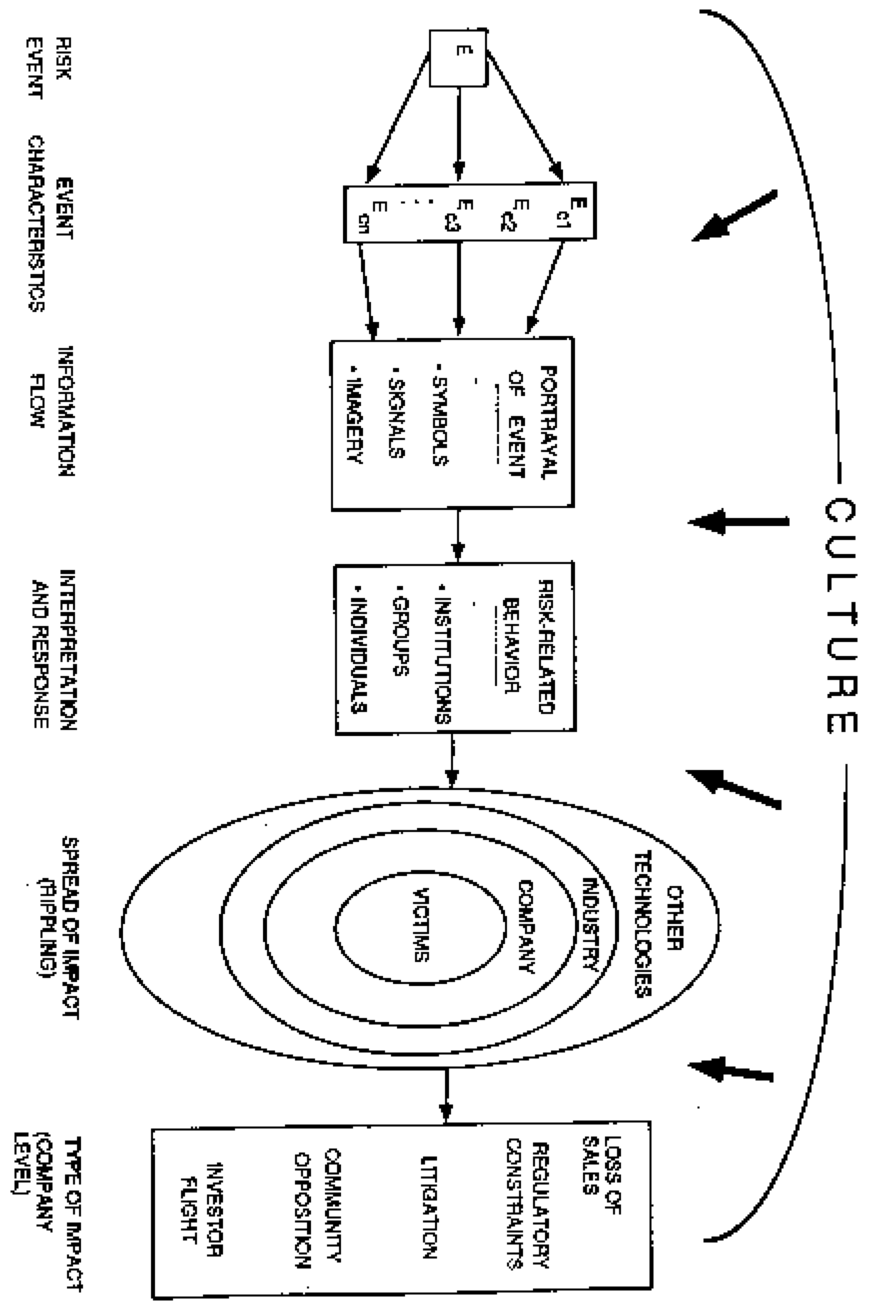
Guides for the Risk Communicator

Every day members of the public in OECD countries are bombarded by risk information. Daily experience carries its arsenal of threats - from industrial accidents, falls on slippery bathroom floors, house fires from faulty wiring, infection by AIDS, and the potential of nuclear war. The mass media abound with accounts of extreme natural events (e.g., hurricanes, tornadoes, floods) or the failures of technology (e.g., airplane crashes or near-collisions, toxic wastes, or the carcinogen *du jour* in the environment). Confronted by this myriad of threats and dangers, publics must somehow navigate their daily existence, choosing which information and events to heed and which to ignore. Since ordinary people have ordinary skills and knowledge, making sense of all of this is no simple task.

Nor is it simple to be the communicator. It is now known that the ways by which risk information is presented can greatly affect public response. Risk communicators are key “stations” in the social-amplification process, shaping the nature of public concerns and placing risks on society's agenda. Which risks should be covered, which ignored? How much coverage should be devoted to a particular accident? Since subtle differences in the presentation of information (framing effects) can elicit very different responses from publics, how may risk-informing be effectively accomplished while minimising exaggeration, misinformation, or unintended manipulation? When should the communicator provoke, and when soothe? Figure 2 provides an overview of what the "consumers" of risk information are looking for in risk-communication programs.

The discussion to follow presents general guides intended to assist risk communicators in being sensitive to the implications of alternatives ways of communicating risk The intent is to demarcate potential pitfalls and problems, and to suggest means for avoiding them (where possible). The suggested guides seek throughout to contribute to more accurate and helpful risk communication and to better informed and prepared publics.

Figure 1. Highly simplified representation of the social amplification of risk and potential impacts on a corporation



Source: Kasperson, et al. (1988, 182)

Figure 2. A consumer's guide to risk and risk communication

WHAT IS RISKY?
Key terminology and concepts
    Hazard, exposure, probability, sensitivity, individual risk, population risk, distribution of risk, unattainability of zero risk
Qualitative attributes
    Voluntariness, catastrophic potential, dreadedness, lethality, controllability, familiarity, latency

WHAT DOES RISK ASSESSMENT CONTRIBUTE?
Quantification
Quality, completeness, uncertainty, confidence
Scientific and policy inferences
    Assumptions, assessment of benefits, risk management choices

WHAT IS THE ROLE OF THE RISK COMMUNICATION PROCESS?
Setting
Public debate about decisions, informing or influencing personal action
Purpose
Messages can inform, influence, or deceive
Interaction among participants
    Contending conclusions, justification, credibility, and records

HOW CAN YOU FIND OUT WHAT YOU NEED TO KNOW?
Technical content
Demystifying jargon, comparing relevant risks, finding trusted interpreters
Independent sources
    Information clearinghouses, academic or public service sources

HOW CAN YOU PARTICIPATE EFFECTIVELY?
Finding the right arena
Identifying the responsible decision-maker, getting on the agenda
Intervention
    Identifying points and times for intervention, marshalling support

HOW CAN YOU EVALUATE THE MESSAGES AND THE COMMUNICATORS?
Accuracy
    Factual base, track record, consistency, self-serving framing, use of influence techniques, misleading risk comparisons
Legitimacy
    Standing, access, review, due process justification
Interpreting advocacy
    Comparing competing arguments, seeing where information has been omitted, questioning messages" sources

Source: U.S. National Research Council (1989, 179)

Choose a good risk measure (or, preferably, several measures). Any given risk or risk event can be measured in multiple ways. Thus, industrial accidents can be characterized by:

- the number of events or releases;
- the number of people (drivers, passengers, victims, bystanders) exposed;
- the number of deaths and injuries;
- the number affected who require medical attention; or
- the number affected who file insurance claims.

Confusion and debates about risk are often the product of differing, perhaps conflicting, measures and numbers. So some observers cite the tens of thousands of persons around the Three Mile Island nuclear plant who received "above-normal" (as compared with background levels) radiation doses, whereas others note that the eventual fatalities were probably near zero.

Viewed systematically, the measure of risk can treat different stages in the evolution of the hazard, as shown below:

accidents--->	**releases--->**	**exposure --->**	**consequences**
number of failures	**number of off-site releases**	**number of persons exposed**	**deaths, injuries, hospitalizations, insurance claims, property damage, loss of trust**

Obviously, risk communication that is comprehensive (i.e., that treats data characterizing the different stages of hazard) is preferable to coverage that treats only a single stage (e.g., releases). In particular, risk communicators should avoid confusing jumps, or discordant data, among different stages.

Reporting on toxic wastes illustrates well the misleading potential involved in dwelling upon one, or perhaps two, stages of risk. Characteristically, the many stories focus upon the amount of wastes at a particular disposal site, the large number of disposal sites, or the numbers of people exposed. The numbers involved are usually frightening. If, however, measures of *consequences* (i.e., harm) are used, the numbers are often very small.

Different measures of risk emerging from the *scope of the risk* category also need careful sorting. The unit of measure can be altered according to whether only *acute* effects (immediate deaths, injuries) are included or if *latent* effects (illnesses, deaths from disease, genetic effects) are also treated. A classic misrepresentation of risk in an important scientific risk document occurred in the so-called Rasmussen Report, the U.S. Nuclear Regulatory Commission study (NRC 1975) of nuclear plant risks, where the *Executive Summary* reported only acute risks, despite their being only one-tenth as high as the latent risk.

In short, the *numerator* of risk really matters.

Include the risk denominator. The measure of risk (i.e., the risk numerator) always relates (often implicitly) to a particular population or aggregate - an exposed group (e.g., air travelers), a period of activity, a measure of production, etc. or the denominator. People may use aggregate data to draw unwarranted implications about individual risk. Evaluating the numbers provided by different expert sources, and depicting the risk to publics, requires careful attention to the denominator. Take the case of coal mining in the United States. Statistics show that accidental deaths *per million tons of coal mined* have decreased steadily over time. Inference: the industry is becoming safer. Data also show, however, that accidental deaths per *1,000 coal mine employees* have increased. Inference: the industry is becoming more dangerous. Neither is the "right" measure; each tells only part of the story (Slovic 1986, 406).

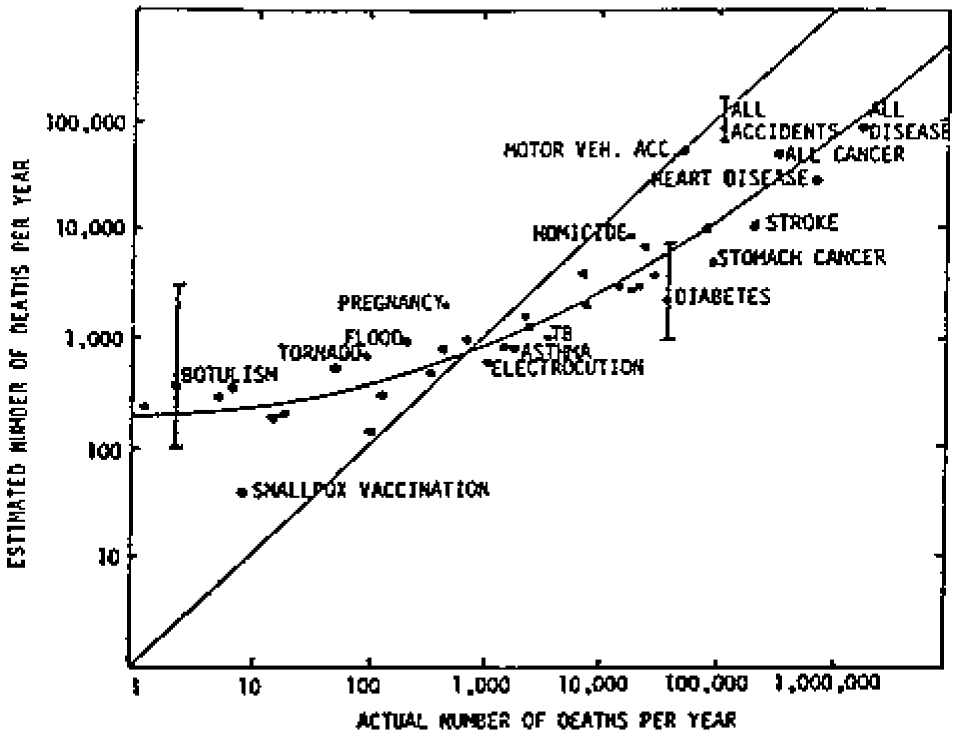
The denominator issue is apparent in environmental hazards whose effects accrue over very long time periods. The environmental standard of protection for high-level radioactive wastes is based upon a 10,000-year time duration and a goal, in the United States, that no more than 1,000 fatalities should be associated with all exposures to waste disposal. The use of absolute numbers - "1,000 people may die from nuclear wastes" - conveys a level of risk very different from the communication that links the fatalities to the large denominator of time "on the average, no more than one person may die every ten years." If the projection notes (which it cannot, with precision) the very large estimated population for the nation, the effect of the risk communication would be still quite different yet.

Help people to think about probabilities. Most people do not readily think in terms of probabilities and so may be expected to have difficulty interpreting quantitative risk information that contains probabilities. The problems arise from various human limitations in dealing with uncertainty. It is a natural human tendency, for example, when confronted by a threat to one's health and safety, to wish to have definite or deterministic statements. "Am I safe or not?" is the recurring question in risk situations - in essence an attempt to impose a binary categorization on a spectrum of probabilities of harm. When individuals have to make decisions that must be made on the basis of probabilistic information, errors are common. Often this involves a failure to recognize the random nature of events or the lack of connectedness in particular occurrences ("Storms run in cycles - we get one every 10 years" or "We had a 100-year flood failure years ago, so we are not in danger for many years yet!"). This is sometimes the result of the so-called "gambler's fallacy" of misunderstanding randomness; other times it reflects an individual's imposing order on uncertainty.

A related problem arises from human limits on processing quantitative data. Probabilistic information that involves very large or very small numbers is particularly problematic, for some risk-communication research suggests that people may compress scales that range over a very large spread of numbers. In an experiment at Decision Research in the United States, lay people were asked to estimate the number of fatalities associated with a wide range of hazards. The results (Figure 3) indicate that people use "heuristics" (simplifying mechanisms) to deal with complex risk data. Respondents frequently overestimate the number of deaths from rare but vivid hazards (e.g., botulism) but underestimate the deaths from chronic, commonplace diseases (e.g., cancer, heart disease). Press coverage of rare and vivid events as compared with more routine and chronic risks may be an important source of public misperceptions.

What do these problems with probabilities suggest for the risk communicator? First, simply announcing the risk probabilities provided by scientists certainly will not be very helpful. People need assistance in interpreting risk probabilities. One approach is to compare a particular probability to events in the public's experience with other risks. Thus, a risk of accidental death of one in a million for a year of exposure might be compared to the risk of being killed by lightning, or, for the frequent air traveller, of being killed in an air crash. Graphical representation of the risk may also be helpful.

Figure 3. Relation between judged frequency and the actual number of deaths per year for 41 cases of death



Source: Uchtenstein et al. (1978)

Be sure to state the uncertainties. The very concept of risk implies uncertainty. It is a common failing to assume that *estimates* of risk are true representations (which they are *not)* of what will actually occur. Estimates of risk, since they project what is expected to happen in the future under some assumed conditions, abound with arbitrary assumptions, imperfect data, and imperfect scientific understanding. For acute hazards where the causality of risks is well understood and where a strong actuarial data base exists, predicting risk is nonetheless risky. For chronic hazards - subject to poorly understood dose-response relationships, inadequate exposure data, confounding variables, potential synergistic effects, and imperfect measurement techniques -risk estimates can (and do) vary dramatically. Simply using alternative extrapolation models of possible effects of exposure to a carcinogen in rats to humans, for example, can produce estimates of risk that can vary by as much as a factor of 10,000 (U.S. National Research Council 1983, 26).

Given this situation, the risk communicator should beware of point estimates of risk. In communicating the risk, it is essential to begin by stating clearly that the estimate *is uncertain.* Next, the *extent* of the uncertainty should be noted. The risk estimate is often best expressed with error bars, or uncertainty limits, that suggest the credible range, as well as the most likely estimate, of the risk. Since most risk estimates are built upon an edifice of assumptions and data, they too need to be made explicit in the communication of the risk. Uncertainty connected with the method, such as in the extrapolation model, should also be specifically noted. A major service that the risk communicator can provide is to bracket the range of credible risk estimation, to indicate the major sources of uncertainty, and (if possible) to state the sensitivity of the estimate to each of the major types of uncertainty.

Give the best case as much attention as the worst. The constant temptation exists to describe risk as the worst it can be. Risk is danger, so one clear need is to know the worst possible. The worst case also makes news - it is the attention grabber. Defining the "worst", of course, is difficult in itself, because if one is willing to conjure up very rare occurrences, then the worst case quickly becomes incredible. So the selection of a “reasonable” worst case is a contentious issue.

But if only the worst case is presented, the public has been poorly served. As Alvin Weinberg (1977, 54) has pointed out, “unscaring people" is much more difficult than scaring them. The tendency for reification of a worst-case estimate needs consideration. Once the worst-case estimate is reported, it often becomes the (rather than one) risk estimate, crowding out subsequent competing estimates. This suggests the need for an even-handed approach, treating the best case as well as the worst case. Even then, the human propensity may well be to recall the worst case rather than the best. But the risk communicator can, by presenting the best case, the most likely case, and the worst case at once, bracket the credible range of the risk for the public.

Note the impact on vulnerable groups as well as “average” people. Risks are not democratic - they do not recognize equality in producing their victims. Some people, because of greater vulnerability, are at greater risk than others. The reasons are both scientific and social, and they are an important part of the risk communication problem.

Quantitative risk estimates typically convey a human toll in the form of abstract representation (numbers). Those numbers generally convey the size and intensity of effect but rarely who the people are. Oftentimes the numbers are aggregate, or address the "average" person, as in occupational health standards. In fact, a given exposure to a harmful substance may affect persons very differently. Increasingly, it is apparent that some persons are much more susceptible (as much as a factor of 10 or 100) than others to a given hazard. Lead in the environment takes a greater toll on children than on adults. The fetus is often highly susceptible to harm from toxic materials, tobacco, or alcohol. Previous experience with lower back pain tends to make a person at higher risk from lifting and even some sedentary activities. Genetic makeup can increase susceptibility to a variety of diseases.

Individuals may also be *socially* vulnerable to risks. Many risks are "hidden" because they affect groups or individuals who are marginal to society, politically powerless, or both. Classic cases include the belated discovery of the Sahelian famine in the 1980s, the toll on workers from asbestos exposure, estrogen hazards to women, or the delayed response to the HIV/AIDS virus.

So the microscope through which risk numbers are examined needs to include a social lens that lays bare the susceptibility of, or impact on, differing racial, gender, and social groups. The communication of risk, accordingly, needs to delineate the spectrum of impact, with particular attention to the most vulnerable.

Be sensitive to the qualitative aspects of the risk. Studies of public perceptions of risk reveal that experts and publics often evaluate the same risk very differently. Although the reasons are not entirely clear, the charge of "ignorance" or "emotionalism" in the public is not the answer. Rather, it is now clear from risk perception research, members of the public apparently take a broader approach than do technical experts in evaluating risk. Characteristics of risk - newness, catastrophic potential, and familiarity - are important considerations in the public assessment of risk. Simple quantitative measures of expected fatalities or days lost from work tend to miss these qualitative dimensions of risk. The clearest example of risk qualities that affect concern is the degree to which the risk is voluntary or imposed. If one is injured when skiing or skydiving, the response is very different from the reaction to the discovery of toxic chemicals in one's back yard. If risks have been concealed and if one's exposure is involuntary, such threats cause highly amplified concern over the risks.

Thus, risk communication needs to be sensitive to the fact that purely quantitative expression of risk may miss what most concerns people. The risk communicator should note carefully the qualities that may socially amplify the risk. Figure 4 provides a useful list of qualities that merit attention.

Include all the consequences that concern people. Just as a hazard event has multiple causes, it also has multiple effects. Accident consequences may be numerous and synergistic, ranging over health effects to worker and publics, losses to the employer, effects on families of those harmed, and perhaps even broader social impacts on the community and society (as through stigmatization of places). For technologies such as chemicals, nuclear power, and recombinant DNA, the risks apparently touch basic human values. Narrow quantitative portrayals of risk miss the consequences about which people are most upset.

Thus risk communication needs to address the broad range of potential consequences rather than a *single* consequence measure of risk. In addition, it should be appreciated that many risk debates fluctuate among different consequences, and the intensity and rhetoric of the conflict may obscure the real problems. Effective risk communication involves assuring that (1) the same consequences are actually the focus of debate, and that (2) all consequences of concern to the public have been included.

Good comparisons help, but poor comparisons mislead and confuse. Because quantitative measures of risk are difficult for most people to decipher and interpret, comparisons are essential. But comparisons may be extraordinarily helpful or extraordinarily misleading. Since every comparison necessarily reveals and conceals at the same time, selection of comparisons must be made very carefully.

In the past, risk analysts have published the risks of widely disparate activities, all of which are standardized to the common metric of increasing one's chance of death during any year by one in a million (Wilson 1979). These lists (see, for example, Figure 5) have appeared widely in newspapers and popular magazines. Although such comparisons may provide insight and perspective, they can also be quite misleading. The lists include risks (e.g., flying 1,000 miles by jet) for which the understanding of the risk is high and a substantial actuarial data base exists but also risks (living two days in New York or Boston) that are poorly understood, whose uncertainties are enormous, and for which few sound data bases exist.

Other essential aspects of the risks - voluntariness, distributional effects, susceptibility to risk reduction, newness - do not make their way onto such lists. Generally, only a single consequence is treated. Sometimes it is suggested (or is implicit) that such lists can be used to guide social action by suggesting which risks are small and which large. Other versions attempt to portray risks by citing the cost of reducing the risk by one fatality per year, with a similar unstated social imperative as to which risks most need to be addressed. Such simplistic, undiscriminating lists are capable of great mischief in misleading the public and can lead to anger against those who provide such poorly formulated comparisons.

Several considerations may help in the selection of appropriate risk comparisons. Comparisons within a risk category (e.g., radiation risks) are more germane than *between* categories. Risk comparisons *for technologies for a particular use* (e.g., generation of electricity, pesticides), which have similar purposes and benefits, have more direct policy relevance. Certain comparisons - such as those that indiscriminately lump together voluntary and involuntary risks or risks affecting different generations - should be avoided. Similarly, statements that compare events involving loss of life from small repeated events with events involving catastrophes are likely to be misleading.

Risk communication is a potentially important aid in assisting publics to understand the risks involved with diverse human activities and technologies. The risk communicator carries a particular obligation to present this information in ways that enlighten rather than confuse, that clarify rather than conceal important properties of the risk, that aid rather than impede valid inferences from the data, and that serve those at risk rather than the managers. Figure 6 provides a checklist of considerations relevant in the design of risk messages. This task calls for recognition that although publics have many shortcomings in their grasp of complexity and uncertainty, most ordinary people manage to navigate their health and safety reasonably well in the uncertain and messy risk domain of advanced industrial societies. They are also, on the whole, quite rational in their response to risk, as risk perception studies have repeatedly confirmed. That fact merits respect in designing risk-communication programs that genuinely respect the capabilities of publics and that seek to inform rather than prescribe.

Figure 4. An array of considerations influencing safety judgments

Risk assumed voluntarily	----------------------------------	Risk borne involuntarily
Effect immediate	----------------------------------	Effect delayed
No alternatives available	----------------------------------	Many alternatives available
Risk known with certainty	----------------------------------	Risk not known
Exposure is an essential	----------------------------------	Exposure is a luxury
Encountered occupationally	----------------------------------	Encountered non-occupationally
Common hazard	----------------------------------	"Dread" hazard
Affects average people	----------------------------------	Affects especially sensitive people
Will be used as intended	----------------------------------	Likely to be misused
Consequences reversible	----------------------------------	Consequences irreversible

Risk assumed voluntarily ---------------------------------- Risk borne involuntarily

Source: Lowrance (1976, 87)

Figure 5. Risks estimated to increase chance of death in any year by 0.000001 (1 part in 1 million)

ACTIVITY	CAUSE OF DEATH
Smoking 1.4 cigarettes	Cancer, heart disease
Spending 1 hour in a coal mine	Black lung disease
Living 2 days in New York or Boston	Air pollution
Traveling 10 miles by bicycle	Accident
Flying 1,000 miles by jet	Accident
Living 2 months in Denver on vacation from New York	Cancer caused by cosmic radiation
One chest x-ray taken in a good hospital	Cancer caused by radiation
Eating 40 tablespoons of peanut butter	Liver toxin caused by Aflatoxin B
Drinking 30 12-oz. cans of diet soda	Cancer caused by saccharin
Drinking 1,000 24-oz. soft drinks from recently banned plastic bottles	Cancer from acrylonitrile monomer
Living 150 years within 20 miles of a nuclear power plant	Cancer caused by radiation
Risk of accident by living within 5 miles of a nuclear reactor for 50 years	Cancer caused by radiation

Source: Wilson (1979, 45)

Figure 6. A risk message checklist

INFORMATION ABOUT THE NATURE OF RISKS

1. What are the hazards of concern?
2. What is the probability of exposure to each hazard?
3. What is the distribution of exposure?
4. What is the probability of each type of harm from a given exposure to each hazard?
5. What are the sensitivities of different populations to each hazard?
6. How do exposures interact with exposures to other hazards?
7. What are the qualities of the hazard?
8. What is the total population risk?

INFORMATION ABOUT THE NATURE OF BENEFITS

1. What are the benefits associated with the hazard?
2. What is the probability that the projected benefit will actually follow the activity in question?
3. What are the qualities of the benefits?
4. Who benefits and in what ways?
5. How many people benefit and how long do benefits last?
6. Which groups get a disproportionate share of the benefits?
7. What is the total benefit?

INFORMATION ON ALTERNATIVES

1. What are the alternatives to the hazard in question?
2. What is the effectiveness of each alternative?
3. What are the risks and benefits of alternative actions and of not acting?
4. What are the costs and benefits of each alternative and how are they distributed?

UNCERTAINTIES IN KNOWLEDGE ABOUT RISKS

1. What are the weaknesses of available data?
2. What are the assumptions on which estimates are based?
3. How sensitive are the estimates to changes in assumptions?
4. How sensitive is the decision to changes in the estimates?
5. What other risk and risk control assessments have been made and why are they different from those now being offered?

INFORMATION ON MANAGEMENT

1. Who is responsible for the decision?
2. What issues have legal importance?
3. What constrains the decision?
4. What resources are available?

Source: U.S. National Research Council (1989, 175)

A robust emergency communication system is one that achieves a continuous, two-way flow of information. All people in the emergency response network, and members of the public, should have as much information as possible, including:

- the current conditions at the plant;
- the movement of any plume or release;
- the current off-site conditions, including local weather and traffic conditions;
- the necessity for certain protective actions; and
- the availability of emergency resources.

At the same time, the authority managing the emergency response should co-ordinate the gathering of information from

- the plant and governmental officials: concerning plant status and possible accident sequences;
- industrial and governmental environmental monitoring teams: concerning weather conditions and any contamination;
- emergency workers: concerning traffic and road conditions, problems at mass-care centres and decontamination stations, and the public response in general; and
- institutions, such as prisons, hospitals, nursing homes, schools, and colleges: concerning their special needs and problems.

A centralised computer system, with backup computer and manual systems, may be useful to assist in gathering, evaluating, and disseminating information about on-site and off-site conditions. Multiple redundant communication channels, including microwave transmission with a relay station, dedicated phones, fax machines, and radios, which link industrial and governmental authorities, are valuable. This redundancy will allow parties to communicate even if some channels fail.

Because the emergency response manager acts as the central focus, gathering and disseminating risk information, it is essential to strengthen “horizontal" links within the hierarchy of communications to avoid over-centralisation. Each local governmental jurisdiction should be able to communicate with the other jurisdictions without having to channel information through a central manager. These horizontal links enable the communication system to function even if the central manager is inoperative. They also allow flexibility to use alternative channels of communication should several channels to one party become blocked. An essential component of such horizontal communication is a pre-established and pre-distributed format for the information that needs to be exchanged. Such a format serves as a checklist for avoiding errors of omission.

Finally, a computerised graphics capability may be an appropriate way to relay much of the necessary information, such as location of a release, traffic problems, and the locations of screening or decontamination stations. Links to local television or radio stations may also facilitate the rapid dissemination of information to the public.

In any emergency, people get information from sources other than industry and government officials. They talk to others at home, in the neighbourhood, and at work. Emergency planners, decision-makers, and emergency workers should recognize this propensity and encourage people to talk to each other. Their goal is to provide clear, comprehensive information in a timely fashion, and thereby to minimise the generation and circulation of false and erroneous information. Rumours abound during emergencies. Once in motion, they are virtually uncontrollable, but their extent and impact can be minimised by providing a consistent and comprehensive flow of information from the beginning and throughout the duration of the emergency.

Evaluating Risk-communication Programs

Effective risk communication that takes account of the social amplification of risk requires a sensitive balance among providing factual information on risk, enhancing protective actions by publics, and avoiding undue anxieties. Evaluation provides a central means for assuring appropriate goals, content, and outcomes of risk-communication programs. Such evaluation has the potential for both good and harm, and requires clear criteria by which to conceptualise and measure success, maximize public safety, and avoid human and ecological harm. Evaluation needs to be a central part of any effective risk-communication program, and not merely an activity to conduct if sufficient funds are left when the program is ended. The following criteria are proposed for evaluating the effectiveness of risk communication.

Appraising communication needs. Risk communication should not be based solely on assumptions by the manager of what those at risk need to know about risks. Rather, a careful appraisal should be made of their needs and how they might best be met. Such judgments should be based on information provided by both experts and publics. It should also include the identification of publics who are especially affected by the risks and how communication can best be tailored to reach them. An explicit formulation of concrete objectives of risk communication is an essential prerequisite for evaluating the results.

Complex risks, diverse publics. Despite the propensity to convey risk in one-dimensional terms (reduced life expectancy, lifetime fatality risk, etc.), risk, as we know, is multidimensional. Technologies have a broad range of consequences, and defining the particular consequence to be assessed is an important decision. The qualitative attributes of risk - voluntariness, catastrophic potential, and degree of familiarity - affect public responses to them. Then, too, cultural groups define risks differently, attach different values to them, and incorporate them into differing socio-political agenda. A primary challenge in risk communication is making complex phenomena understandable to non-technical people while simultaneously capturing the major attributes of concern to a highly variegated public. In such situations, it is important to err on the side of multiple perspectives, differing characterisations of risk, and richness in communication approaches.

Risk in context. Accident risks are a complex phenomenon, at once technical, uncertain, probabilistic, and value-laden. Provision of information needs to be accompanied by efforts to assist individuals in comprehending the risk. Types of contextual information include comparisons with other relevant risks (which need to be done with intelligence and sensitivity); comparisons with benefits of the activity or technology; comparisons with regulatory standards or natural background levels, etc.; and comparisons of ways in which the risk can be reduced. Invariably, individuals also desire, and may demand, full information on the industrial installations and processes that generated the risk - what accidents may occur, what materials may be released, what is being done to prevent or reduce accident risks, and how publics may protect themselves from accidents.

A management prospectus. As suggested by BArch Fischhoff (1985), risk managers should develop a protocol that ensures that all relevant information concerning the risk management program is communicated to the public. Such a prospectus would include how the manager sees the facts, what options the manager is legally empowered to consider, what the manager considers to be the public interest, how risk decisions are (or will be) made, and with what envisioned results. A well-thought-out treatment and presentation by the managers is greatly preferable to speculation on such matters by the mass media or piecemeal construction of the picture over time. Prompt provision of such information and openness to public scrutiny may head off fears that the manager is withholding relevant facts or has hidden motivations.

Timeliness. Risk communication should be timely, meaning that it should occur early enough in any accident situation to alert the individual to the risk so that protective actions can be taken to avoid it or to minimize adverse consequences. A common error is for risk managers to withhold information until late in the process, when information and evidence are more complete and control strategies and supporting rationales more fully developed. It is possible, however, for communication to be premature, thereby eliciting unwarranted fear or unnecessary protective actions. Repeated over-reactive warnings to evacuate in the face of a predicted natural hazard (e.g., hurricane) or industrial accident (e.g., a chemical release) may result in decreased credibility and, thus, increased risk.

Iterative interaction. Although there may be special circumstances in which risk communication involves only a single transaction or message, multiple or continuous interaction is nearly always necessary to ensure a flow of relevant risk information. Interaction implies the two-way flow of information, with learning by all those participating in the process. Too few risk-communication programs build in the means for risk managers to listen to or to initiate public response, which should be a requisite to developing the communication program and gauging its effectiveness. There are many good lessons here from the background paper by Knowles (1995) on the Kanawha Valley experience.

Empowerment. Risk information unaccompanied by appropriate means to use and to act on the expanded knowledge is ultimately frustrating. Clearly, it reduces the incentive to acquire risk information and causes publics to ask: “If I can't do anything about it, why are you telling me?". Wherever possible, risk communication should be embedded in a broader approach that empowers those at risk to act in their own protection or to influence those who are managing risks and accidents. The effectiveness of trade union information programs on workplace hazards, as described by Aro (1988) in the background document for the OECD meeting in Sweden, is connected in no small part to worker participation in risk management programs.

Credibility. Success in risk communication depends heavily on the confidence individuals place in the sources of information. Credibility is multidimensional, involving how publics view managerial competence, commitment to public health and safety, and caring about those who bear the risks.

Ethical issues. The risk communication initiatives of the OECD and others assure that a great many campaigns will continue to develop and that experience will grow rapidly. Safeguards are needed that reflect thoughtful deliberations on potential ethical issues involved, including:

1. identification of unintended adverse consequences in programs and of structured means for avoiding them;

2. respect for the autonomy of the individual and avoidance of paternalism;

3. recognition of potential self-interest or bias in the institution acting as risk communicator;

4. respect for the rights of those bearing the risks so that programs will be responsive to them;

5. means to ensure that risk communication will be compassionate and respectful of those addressed by the communication;

6. avoidance of undue worry and fear;

7. assurance that managerial personnel will have the right to refuse to engage in unethical conduct.

To assure that these ethical issues are addressed, the creation of codes of conduct for risk communicators would be helpful.

Resiliency. Since we can claim only limited understanding of how best to accomplish the goals of risk communication, false steps and faulty approaches are virtually certain. A well-designed risk-communication program should therefore expect and plan to accommodate surprises and failures. The designers and implementers of such programs should take in stride the inevitable conflict (noise) among different sources of information; the occurrence of unforeseen events; the potential roadblocks in some channels of communication; deficiencies in identifying all citizens and groups at risk; the existence of unidentified value structures and community agenda; the prevalence of higher levels of distrust than previously assumed; and wide divergence in the risk judgments of experts and publics. Anticipating problems will go a long way toward achieving a resilient process that permits the flow and delivery of information, promotes requisite interactions with publics, and enhances credibility in the face of adversity and of the unexpected, which, after all, always happens.

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COMMUNICATING WITH THE PUBLIC:

RISK MANAGEMENT AND WORST CASE SCENARIOS:

THE KANAWHA VALLEY EXPERIENCE

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The opinions expressed in this document do not necessarily represent the opinions of the OECD or its Member countries and should therefore be viewed solely as those of the authors.

Introduction

This is the story of a great adventure by everyday people who learned to fly together. We learned to bring our community together in a way that opened up communications and built trust. This is a story about trying to build a more sustainable community where the need for an improved and safer environment is being balanced with the economic benefits of our industry in the Kanawha Valley.

This is a story about community leaders, first responders, emergency response planners, hospitals, Red Cross, environmentalists and industry people struggling together in a process lasting for over two years. We opened up to each other, we shared lots of information, and developed the technology and communications necessary to share risk management plans and worst case scenarios with a community of about 250,000 people. This was done in a community where there is a lot of tension between the plants and the environmental and labor groups as well as with the media.

Risk Management and Worse Case Scenarios

All this culminated on June 3 and 4, 1994, when the 13 plants shared 29 worst case scenarios with the community; trust went up, and outrage was lowered. This is where we all need to be so that we can work together to address the deep, tough problems like reducing the impact of toxic materials, environmental justice, and finding the appropriate balance between a safe and environmentally sound industry and economic development.

This all began in January 1992, when Ms. Pam Nixon, chairperson of the Citizens Concerned About Methylisocyanate and member of the Kanawha/Putnam Local Emergency Planning Committee (K/PLEPC), asked the plants in the Valley to share their three worst case scenarios so the K/PLEPC could plan more effectively. This request was well in advance of the Clean Air Act requirements which will require many businesses and other organizations to communicate their Risk Management Plans (RMP) and worst case scenarios; the rule may be issued in early 1996 and become effective three years later.

As we in the plants first considered this request, we really struggled with it. In the beginning, we tried to find ways to get around having to do this because we simply didn't know how to do it. We were being criticized almost daily in the newspaper, and worst case scenarios would add fuel to that bombardment. There were many concerns and questions no one had addressed before such as:

Worst case scenarios

- No Federal guidance beyond Green Book
- How to model
- What compounds to select
- What assumptions to use in the models
- Who should communicate?
- What to communicate?

- How should the various plants, companies involved, and industry respond?
- Communicate one at a time, in groups, all together?
- Why respond at all right now, rather than waiting for Clean Air Act rules to go into place?
- What's the LEPC's role in the process?
- LEPC (at that time) didn't have the knowledge or skills to do it?
- How can we be credible in the industry?
- How do you communicate something this complex to 250,000 people?
- Is this going to drive us out of the Valley?
- What will happen to property values?
- Etc.

The reality

- We were faced with a challenge that could threaten the existence of our facilities if we didn't do the communications openly, thoroughly, and well.
- We had only one chance - there'd be no dress rehearsals.

Recognizing the scope, depth, and potential impact of this more quickly than the others, we stepped into the middle and took up the role of trying to address all these questions and many more that came up.

One author, R.N.K., has been on the CMA CAER Task Group for seven years and the WV-SERC for three years and has had a lot of experience working “m communities and communicating risk. Before coming to the DuPont Plant in Belle almost eight years ago, he'd been Plant Manager at our plant in Niagara Falls. He can assure you that operating a chemical plant within four miles of Love Canal was an educational experience.

The story I'll share today is about a group of ordinary men and women who came together discovering our community, getting to know each other, and sharing an immense amount of information, openly and freely, building hart together.

I hope you'll get insights on how you might address this in your own communities.

As we moved forward in considering the task, a plan and process developed that we believed would have the best chance to build the necessary trust for this communications process to work.

Table 1. Companies involved

Arco Chemical	2 facilities
DuPont	1 facility
FMC	3 facilities
Monsanto	1 facility
Olin	1 facility
Occidental	1 facility
Rhône-Poulenc	1 facility
Union Carbide	3 facilities

The Trust Building Process

- Find a way to discover and connect our values in a person-to-person way, each of us as individuals who care about our community.

- Include a broad cross-section of the stakeholders in the process:

  - public leaders
  - industry people
  - regulators
  - first responders
  - hospitals
  - environmentalists
  - students

- Committee chairpersons were volunteers from the public. (Committees are described a little later in this paper.) The active, real involvement of these people greatly influenced the final results; authenticity and trust were built. The industry people were deeply involved through the entire process as partners in it.

- Information was freely and openly shared with the committees, which put everyone on the same footing. Ground rules were developed, the desired outcome established, and the way information would be controlled prior to public release was agreed upon.

While this sounds fairly simple, it took a lot of time and energy to build the authenticity and trust for the process to work. This process can be used in any community; using it will result in each community developing the appropriate way that RMP's and worst case scenarios can be shared that's best for their unique situation.

In the Kanawha Valley, all the chemical plants are spread out along the Valley with DuPont and Oxy about 10 miles east of Charleston and the rest stretching along the Valley to the west of Charleston for about 15 miles. Since we are all essentially in the same community, we decided that it would be better to respond to the worst case scenario request as a group rather than as individual plants. Our plumes could impact each other, and we're all covered by the same media people. We felt the communication task would work better if we did it all together.

At the beginning, we realized that we needed two committees to develop all this work. The EPA had not issued any proposed rules for how to do this under the Clean Air Act, so a lot of technology had to be developed, like the definition for a worst case scenario, how many other more likely scenarios should be considered, model selection, the assumptions to be used in the modeling, how to select the right materials to be used in the studies, how to bring some alignment among the various plants and companies on all this, and much more. To address this, a Hazards Assessment Committee was formed which was chaired by Dr. Paul Hill of the National Institute of Chemical Studies (NICS).

The other committee we formed was the Communications Committee, which was co-chaired by Sally Shephard (involved in the Kanawha Valley recycling programs), Mary Frances Bleidt (a community leader) and Tom Nunheimer (from Arco). We had to work very hard, going over the same ground a lot at first as we tried to figure out how to get our arms around this thing.

We also agreed early in the process that these committees and the whole RMP-worst case scenario process needed to be done under the auspices of the K/PLEPC, who have the responsibility to develop the community emergency response plans.

It was also agreed that an outside, independent party was required, who was responsible to the K/PLEPC, to help us develop the technology and be a referee among the plants so that there would be more credibility in the work that was developed. Through a competitive bidding process, the K/PLEPC hired JBF Associates to do this. Beginning with the EPA Green Book, JBF helped us develop a sound technology base and solid results.

Because this work was of such a pioneering nature, Craig Matthiesen and Lyse Helsing, both of the EPA involved in writing the Clean Air Act rules, were invited and participated in a number of the meetings of both committees. This was a great learning experience for all of us; no one had all the answers on how to do this.

As the Hazards Assessment Committee moved along, the Communications Committee began to come together. We agreed that we'd all use the RMP, as proposed by the EPA, to be the framework for each plant to communicate their scenarios. We'd show a worst case, a more likely accident scenario, the layers of protection in place as described in the proposed 112R rule which are designed to prevent releases, emergency response plans, our accidental release history (essentially, all releases over the last five years plus any large one from earlier years), and the uses for the materials we were describing.

We developed an insert for the newspapers to use just before the public meetings to talk about all this work, tell who was involved, talk about the LEPC, and provide definitions of the terms people would be hearing. It provided information on the place and date of the presentations.

Through a competitive bidding process, the K/PLEPC hired a public relations firm (Charles Ryan Associates) to help us with community surveys, plan for the details of the event like getting the meeting places, etc.; they were not hired to do the communications itself, however. This was to be done by the plant managers for their own materials and the leadership of the LEPC.

During the course of all this work on the communications, we became aware that we were really beginning to bring our community together in a new way that was really quite exciting. Trust was building; something new was happening. In the community surveys and in discussions with other community people, we realized the key question went like this: WE KNOW THAT YOU GUYS CAN KILL US - JUST TELL ME WHAT YOU ARE DOING TO PREVENT THAT FROM HAPPENING.

We agreed to name all this "Safety Street: Managing Our Risks Together." In the name itself, we tried to convey this new sense of community.

We also agreed that this task was so complex that we'd need to develop a comprehensive program that would share all aspects of the RMP with the public. A two-day event was selected, a Friday and Saturday, so everyone who was interested could attend. On Friday, June 3, 1994, we decided to have a series of formal presentations on the background of all this and share the process that was used in developing it. This was to be followed by presentations by two Plant Managers using two real scenarios so people could see how all the data would be presented. The first scenario was shared by Dr. Richard N. Knowles of DuPont; the ammonia example resulted in the largest scenario in the Valley. The second scenario was shared by Van Long of Rhône-Poulenc; the methylisocyanate example was material of the highest interest in the Valley. The program looked like this:

Safety Street: Managing Our Risks Together - June 3, 1994
9 AM - Early Afternoon - Charleston Civic Center

Dr. Paul Hill	NICS	Welcome
Craig Matthiesen	EPA	Who/What/History of LEPC National Context
Pam Nixon	Citizen Member - LEPC	Original Request
Mark Wolford	KVEPC Director	Emergency Preparedness
Steve Hardman	K/PLEPC Fire Chief	Emergency Preparedness
Lillian Morris	Safety Director CAMC	Emergency Preparedness
Pat Conlon	Monsanto	Process Safety Management
Steve Arendt	JBF	Technical Overview
Questions and Answers		
Dr. Richard Knowles	DuPont	Ammonia

Van Long	Rhône-Poulenc	Methylisocyanate
Buffet lunch		
Plant managers	Review their individual cases at tables in the large hall	

After the formal presentations in the Charleston Civic Center auditorium, which seats 700 people, we moved to the large hall where each plant had set up with a display booth like a trade show where people were available to discuss the RMPs and give RMP summaries to those who were interested. This enabled everyone to find out what they wanted in one-on-one personal discussions with the Plant Managers and their staffs.

In our initial thinking, this same format would be used both days. However, the community survey indicated that most people would not come to the Civic Center on a Saturday to listen to the Managers. The women on the Communications Committee strongly recommended that we should take our story to the Town Center Mall, the biggest shopping center around. After some struggle, the Plant Managers agreed. In the Mall, we set up our booths just as they were on Friday; and we were there all day to talk with anyone who was interested. We were also able to talk with people about their responsibility to know how to shelter-in-place and gave each one a plaque which had shelter-in-place directions on it to put on their refrigerator or cupboard.

In addition to the plant displays, we agreed that the first responders, NICS, the K/PLEPC, hospitals, Red Cross, and environmental groups could have displays; our ground rule was that anyone wanting to have a display had to be connected with the K/PLEPC. The whole community was brought into the room together.

All the funding for this effort was provided by the plants, based on the number of scenarios we each had to share. The money was provided to the K/PLEPC and administered by NICS. The total out-of-pocket costs were about $100,000-$125,000 for the event.

In the weeks leading up to Safety Street, there was a lot of media attention and much criticism directed at trying to discredit the whole effort. At one point, the Charleston Gazette said we were going to be lying, even before we had a chance to say anything.

Also in the months prior to this event, both Rhône-Poulenc and DuPont developed community ambassador programs where we trained some plant people about our work in protecting the environment and asked them to go out into our local areas to talk to schools, Lions Clubs, and other groups.

Just before the event, the Plant Managers talked with the local fire departments, who had already had some involvement about the Safety Street events. We also talked with elected officials and our Community Advisory Panels.

On June 3, 1994, about 700 people came to hear the formal presentations; about 1/3 were from out of town (lots of representatives of the chemical industry were interested in this), 1/3 from the community, and 1/3 from the local industry. On June 4, 1994, about 3,000-5,000 people visited our displays in the mall from the 10 AM opening to the 9 PM closing. There was no reactive behavior or demonstrations. There were lots of genuine questions and deep interest in what we had to share. We each tried to make our displays and discussions meaningful and easy to understand. Our booths were staffed by engineers, managers, and hourly people (in some cases) who had been involved in the planning and helping to develop the displays.

The media coverage was extensive and pretty well balanced. We shared far more information than anyone expected, more openly than ever before. In addition to the local media, the New York Times and CNN provided coverage which was low key and balanced.

During the open discussions and dialogue, trust continued to build; and expectations for more dialogue were raised. The plant managers as a group were more open and available than ever before, which helped to build the credibility of the process. At the end of the day on Saturday, we all felt extremely good at how well everything had gone and the high level of interest shown in our work.

Since then, several groups have gathered together to reflect on the key learnings developed from all this.

Key learnings:

- The process works - it's as important as the event itself. Authentic participation in the process built trust.

- Broad, meaningful involvement by all the stakeholders was vital.

- Committees led by community leaders and the K/PLEPC helped to build trust and bring the community together.

- Having the critics involved in the process and the displays also helped to build trust and bring us together.

- Openly sharing lots of information put us all onto a more equal footing.

- The extensive interaction we all had with the media helped give them the background they needed.

- Doing a credible job, building the trust, resulted in balanced coverage by the national media.

- Taking the message to the community, rather than expecting them to come to us, enabled us to reach more people and show them we were trying to be more open.

- We went a long way towards answering the question - WE KNOW YOU GUYS CAN KILL US; WHAT ARE YOU DOING TO PREVENT IT?

- In our community, anything less than this would not have worked.

Where trust is built, options to solve problems open up. Where there is no trust, the only option people have is to make us stop using materials which they believe will hurt them. In a more trusting climate, we can engage in discussions of other ways to reduce the potential impact of hazardous materials.

Epilogue

Now the Community Emergency Response Evaluation Group (CEREG), a subcommittee of the K/PLEPC, is meeting with each plant to evaluate emergency response plans in the facilities, look at the learnings and changes that resulted from previous releases, and look at the community emergency response plans for coverage and completeness. As these studies develop, the results will be communicated in each plant community; at Belle, we worked with the Upper Kanawha Valley Community Advisory Panel to do this. Several people from the CAP worked on the CEREG study for Belle. The trust that we built is fragile and needs constant nurturing. We still have a long way to go.

There was no negative impact on the plants or property values as a result of this work. The dialogue continues as the K/PLEPC is working with each community, looking at the scenarios, evaluating plans, and strengthening them where weak spots or voids were discovered.

APOLLINAIRE SAID:

"COME TO THE EDGE"

ITS TOO HIGH

"COME TO THE EDGE"

WE MIGHT FALL

"COME TO THE EDGE"

AND THEY CAME

AND HE PUSHED THEM

AND THEY FLEW!!!

Further OECD Work on Risk Assessment in the Context of Chemical Accident Prevention, Preparedness and Response

This report contains the Conclusions and Recommendations of the OECD Workshop on Risk Assessment and Risk Communication in the Context of Accident Prevention, Preparedness and Response (see pages 11-24).

Based on the Conclusions and Recommendations of the Workshop, the OECD's Expert Group on Chemical Accidents agreed to undertake a project aimed at improving understanding and communication with respect to the assessment of risks related to chemical accident prevention, preparedness and response, and to facilitate the use and choice of approaches for undertaking such assessments.

To achieve this objective, the project is directed to the development of two products. The first is a computer database containing a "thesaurus" and supporting material which make more transparent the intended meaning of terminology and documentation associated with the risk assessment process as used in different countries and organisations. The second product is a "manual" in which a range of information is collated concerning different risk assessment methodologies in a way which will allows the user to better understand the nature of the risk assessment process and its outcomes, and to improve the choice of a methodology which would be the most appropriate under specific circumstances (including, for example, legal and cultural context, resource availability, technical context).

The basic assumption underlying the approach chosen for the thesaurus is that the various steps involved in the risk assessments of hazardous installations can be described in objective, operational language. This language improves the transparency of words/phrases despite the fact that various countries and organisations may use different words/phrases to describe similar steps or may use the same words/phrases in the context of different steps. The use of operational language should therefore increase understanding and allow for comparisons among different approaches.

The project will *not* seek to harmonize terminology, nor will it attempt to judge the relative value of different methods.

These products will be made available through the Internet. They are intended to be valuable to a wide range of interested parties, including regulators and other public authorities, industrial managers, technical experts, workers and their representatives, community-based organisations, and others who need to undertake or understand risk assessment as it relates to chemical accidents, as well as those who wish to learn from the experiences of others.

Since users will have widely differing levels of expertise and experience, both the thesaurus and manual will be developed in such a way as to be understandable and useful to the "informed lay-person" while providing experts with valuable information and tools for their work.